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THE UNIVERSITY OF HONG KONG

IMPACTS OF THE INDOOR ENVIRONMENT ON THE HEALTH OF OCCUPANTS IN OPEN-PLAN OFFICES IN HONG KONG

A DISSERTATION SUBMITTED TO THE FACULTY OF ARCHITECTURE IN CANDIDARY FOR THE DEGREE OF BACHELOR OF SCIENCE IN SURVEYING

DEPARTMENT OF REAL ESTATE AND CONSTRUCTION

BY

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HONG KONG

APRIL 2004

Declaration

I declare that this dissertation represents my own work, except where due acknowledgment is made, and that it has not been previously included in a thesis, dissertation or report submitted to this University or to any other institution for a degree, diploma or other qualification.

Signed: _____

Name: NG WUN YIN

Date: 15-4-2004

ABSTRACT

In recent decades, open-plan layout with air-conditioned indoor environment is the most common design for office buildings in Hong Kong. This type of building design can reduce construction cost, energy cost and allows a flexible arrangement of space. However, this type of building design usually incorporates central-control systems which allow few controls on the indoor environmental conditions by occupants. This design is also vulnerable to potential indoor pollution problems which affect the health of occupants. The term 'sick building syndrome' (SBS) was introduced by the World Health Organization in 1983. SBS is the problem of building related health symptoms reported by occupants. Unfortunately, not until recent years, concerns about the adverse health effects of poor indoor environment are aroused in Hong Kong.

In sight of the importance of a good indoor environment on the health of occupants, this dissertation serves four main objectives. First is to analyze the concerns by government and private organizations on the importance of the indoor environment. This was done by comparing relevant government policies and legislations and the private sector participations in Hong Kong and selected overseas countries. Comparative analysis reveals that regulatory controls on the indoor environment are fragmented in various ordinances in Hong Kong. This hinders the effectiveness of enforcement. Most regulations and guidelines concern mainly about the indoor air quality and the ventilation systems. The importance of other aspects of the building fabric as well as property management in creating an ambient indoor environment is usually neglected. Private sector participations to alleviate the problem of building related health complaints are limited in Hong Kong.

Secondly, a comprehensive review on open-plan offices and the causes of building related health complaints are offered. This was mainly done by critically reviewing literatures from previous studies in the same area.

To further investigate the impacts of indoor environment, an empirical study was conducted in Hong Kong. The empirical study investigated the relationship between conditions of the indoor environment and health complaints by occupants. The study was based on four selected buildings with different ratings under the Hong Kong Building Environmental Assessment Method (HK-BEAM) scheme. Buildings with different ratings under the HK-BEAM scheme were used as a proxy to reflect the differences in the indoor environmental conditions. Moreover, the relationship between the degree of personal controls on the indoor environment and the adverse health effects on occupants was also investigated in this empirical study. Face to face questionnaire surveys were used to collect the necessary data. Information about the perceptions and the degree of personal controls on the indoor environment as well as the health problems perceived by office workers was collected. The data were analyzed using well designed indexes. The empirical results suggest that in office buildings, the indoor air quality is less than satisfactory when compared with other factors identified. Moreover, personal controls by the occupants on the indoor environmental conditions are limited. The health complaints reported also suggest that a good indoor environment is important for the health of occupants.

Lastly, recommendations are suggested based on the findings which help to create a good practice for building designers and property managers. Solutions are provided to professionals to alleviate building related health problems. A good working environment can then be created by incorporating proper designs and effective property management strategies to buildings.

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TABLE OF CONTENTS

LIST OF ABBREVIATIONS

HKSAR	Hong Kong Special Administrative Region
IAQ	Indoor Air Quality
SBS	Sick Building Syndrome
WHO	World Health Organization
HK-BEAM	Hong Kong Building Environmental Assessment Method
AS	Australian Standards
BOMA	Building Owners and Managers Association, Australia
ASHRAE	American Society of Heating, Refrigerating and Air-conditioning Engineers
AIHA	American Industrial Hygiene Association
ACGIH	American Conference of Governmental Industrial Hygienists
CMHC	Canada Mortgage and Housing Corporation
BEPAC	Building Environmental Performance Assessment Criteria
BREEAM	Building Research Establishment Environmental Assessment Method
HSE	Health and Safety Executive, United Kingdom
HVAC	Heating, Ventilation and Air Conditioning
EPA	U.S. Environmental Protection Agency
OSHA	Occupational Safety and Health Administration
DOE	Department of Energy, United States
ANSI	American National Standards Institute
NIOSH	National Institute for Occupational Safety and Health
CBVIEQ	Commercial Building Ventilation & Indoor Environmental Quality, United States
USGBC	US Green Building Council
LEED	Leadership in Energy and Environmental Design
SISIR	Singapore Institute of Standards and Industrial Research
GN	Guidance Notes for the Management of Indoor Air Quality in Offices and Public Places
SARS	Severe Acute Respiratory Syndrome
EMSD	Electrical and Mechanical Services Department, HKSAR
EPD	Environmental Protection Department, HKSAR
ASD	Architectural Services Department, HKSAR

HBI	Healthy Building International Pty. Ltd
OSHC	The Occupational Safety and Health Council, HKSAR
CUHK	Chinese University of Hong Kong
BSRIA	Building Services Research and Information Association
CIBSE	The Chartered Institute of Building Services Engineers
VOCs	Volatile Organic Compounds
MTR	Mass Transit Railway
ECI	Environmental Comfort Index
PSI	Person Symptom Index
BSI	Building Sickness Index
FII	Frequency and Intensity Index

CHAPTER ONE

INTRODUCTION

1.1 Introduction and Significance of the Research

It is generally recognized that people nowadays spend 80% or even more of their time at homes, in offices and other indoor environment. The indoor environment thus has significant impacts on human beings. Indoor pollutions and improper environmental conditions which affect the health of human beings are the most sensitive and important aspects for considerations. Despite this, government efforts are concentrated on tackling problems about the outdoor environment and outdoor pollutions. Government policies of most countries and cities, including Hong Kong, pay little attentions in regulating and creating an ambient indoor environment. However, in recent years, comparative risk studies performed by the US Environmental Protection Agency and its Science Advisory Board have consistently ranked indoor air pollution among the top five environmental risks to public health (US EPA, 1993).

Public concerns on the importance of the indoor environment are aroused in recent decades in Hong Kong. This is mainly due to the media reporting health complaints from office workers. In the Second Review of the '1989 White Paper on Pollution in Hong Kong' published in November 1993; the HKSAR Government stated the potential problems and health risks associated with indoor air pollutions. A study sponsored by the Government was conducted during 1995-1997. Occupants in forty offices in Hong Kong were covered in a questionnaire survey. The results indicated that about one third of the occupants surveyed were dissatisfied with the

indoor air quality (IAQ) of their respective buildings (EHS Consultants Limited, 1997).

The construction of completely sealed commercial building shells has lead to potential indoor pollution problems. The term 'sick building syndrome (SBS)' was introduced by the World Health Organization (WHO) in 1983. SBS is defined as an excess of work related irritations of skin and mucous membranes and other symptoms, including headache, fatigue, and difficulty concentrating, reported by workers in modern offices. The health problems are lessen or disappeared when the occupants are away from the problem buildings (WHO, 1983). For simplicity, the adverse health effects resulted from indoor environmental problems are referred to as 'sick building syndrome' in this study. The WHO also identifies a number of features that are common to sick buildings: they often have forced ventilation, of light construction, the indoor surfaces are covered by textiles, energy efficient by keeping a relatively warm and homogeneous thermal environment and airtight in which windows cannot be opened (WHO, 1982).

Offices nowadays in Hong Kong tend to have open-plan layout in a completely sealed environment. This type of building design can reduce construction cost, energy cost and allows a more flexible space arrangement. However, this type of building design is also most vulnerable to result in poor and health risking indoor environmental conditions. If the indoor environment created inside this sealed environment is not properly monitored and managed, then adverse effects on the health of occupants and reduction in productivity may be resulted.

Buildings should not be treated solely as fixed assets in which corporation performances take place but as a variable in the production process. Therefore, a physiological, psychological and environmental friendly workplace can increase productivity. Poor indoor environmental conditions can result in significant adverse impacts on our health. These impacts carry a significant cost burden to the economy.

Woudhuysen (1990) points out that artificial lighting has to be used all the time is regarded as unhealthy. Too bright and glaring cause complaints about headache and eye strain. He also suggests poor air quality in offices related to incidence of illnesses. Isozor et al. (2001) suggest that the prevalence of harmful natural and artificial substances indoors, combined with poorly ventilated interiors and the long period of time staff spend indoors, can lead to various health problems. Leaman (1992) suggests that as the layouts of open-plan offices tend to be relatively large in size, if these offices are not properly managed, they are much more likely to be more unpleasant for occupants.

Concerns about the importance of the indoor environment on the health of occupants are increasing. However, there are a few researches conducted in this area to reveal the situation. No conclusive evidences about the causes of building related health complaints are identified. There are even less concerns and researches on the issue in Hong Kong. Open-plan layout with air-conditioned environment is popular in office buildings in Hong Kong. It is important to identify some practice and benchmarking criteria for the indoor environmental conditions in this type of office buildings to safeguard the health and well-being of the occupants.

1.2 Hypothesis and Objectives

The hypothesis of this study is 'Bad indoor environment and low degree of personal control on the environment in office buildings can cause adverse health problems to the occupants.'

The objectives of this study are firstly to analyze the concerns by government and private sector on the importance of the indoor environment. It is a comparative analysis to reveal the situations in Hong Kong and selected overseas countries. Secondly, it reviews the causes of building related health complaints which act as the basic for the study. Based on these, further investigations on the effects of a bad indoor environment on the health of occupants are conducted by an empirical study in Hong Kong. Moreover, the relationship, if any, between the degree of personal control on the indoor environmental conditions and the adverse health impacts to the occupants are analyzed. Lastly, recommendations are suggested to building designers and property managers to solve the problem of building related health complaints in office buildings in Hong Kong.

1.3 Methodology

Questionnaires are used for the collection of necessary data for this study. The target group is the office workers in four office buildings certificated under the voluntary Hong Kong Building Environmental Assessment Method (HK-BEAM) scheme. The four target buildings are carefully chosen so that they are buildings with the four different ratings under the scheme. Face to face questionnaire surveys are conducted to collect information about the perceptions and personal control on the indoor environment as well as the health problems perceived by the office workers in

these four buildings. Data are analyzed using indexes and conclusions are drawn from the results of the study to verify if the hypothesis mentioned before is accepted.

1.4 Research Outline

The plan of this research is as follows. First, the concerns for the importance of the indoor environment in overseas countries and that in Hong Kong are presented and analyzed. This is done mainly through comparisons on the current legislations, guidelines, technical codes of practice and private sector participations in the selected countries and in Hong Kong.

Second, the reasons for the popularity of open-plan offices, results of previous researches on the issue of building related health complaints or 'sick building syndrome' (SBS) and the causes of SBS are reviewed critically and comprehensively.

Third, the methodology used for the empirical study in this research is presented in detail. The rationales for the use of face to face questionnaire survey, the sample selection, the pilot study, the questionnaire design as well as the data analysis methods are further discussed and developed.

Fourth, the results and implications of the empirical study are investigated and interpreted. Recommendations and benchmarking criteria for an ambient indoor environment that can create a healthy working environment to office workers are proposed.

Last, conclusions about this study are established. The limitations of this study with suggestions for further research in this area of study are offered

CHAPTER TWO

SITUATIONS IN SELECTED OVERSEAS COUNTRIES

2.1 Introduction

People nowadays spend most of their time indoors. The indoor environmental conditions of buildings have great impacts on occupants, especially on the health of occupants. The adverse impacts of the indoor environment on the heath of occupants have attracted many concerns. Developed countries are more aware of the problem. Legislations, regulations, codes of practice and guidelines are established and implemented in these developed countries by the governments and various related professional bodies. This chapter reveals the legislative frameworks and the control mechanisms for indoor environment in eight selected foreign countries. It is based on the findings of the consultancy study by the EHS Consultants Limited in 1997. Up-dated information is also added to give a more realistic picture. The selected countries include five well developed countries, namely, Australia, Canada, United Kingdom, United States and Sweden. Situations in three Asia countries which are near to Hong Kong, namely, Japan, Singapore and South Korea are also reviewed. The experiences of these countries provide information useful for the development of proper regulatory controls and guidance mechanisms for indoor environmental problems in Hong Kong.

2.2 Australia

2.2.1 Legislative Framework

Each of the nine jurisdictions in Australia has a different set of legislation. The regulations and legislations for the issue of indoor environment rest on individual states and territories. Indoor air quality (IAQ) legislations fall into two categories which are the Occupational Health and Safety and the Public Health. Office buildings are buildings under the regulation of the Public Health legislations.

Two main federal agencies, the National Occupational Health and Safety Commission (Worksafe Australia) and the National Health and Medical Research Council develop standards for the issue of indoor air quality. These standards and guidelines are often called up in related legislations in various jurisdictions. Another professional body is the Standards Australia which comes from the Standards Association of Australia. A wide range of national standards, including indoor air quality standards are developed by this professional body.

Liability issues associated with indoor air quality have been dealt with under common law and statute law in Australia (Gilbert and Black 2000). Under common law, building occupiers owe a duty of care to persons entering the premises. This duty of care is breached if reasonable precautions are not taken (Immig et al 1997). The duty of care owed is greater to persons at greater risks. For example, because of their greater susceptibility to an illness or if the consequences of injury are greater.

2.2.2 Related Standards and Guidelines

Ventilation systems have great impacts on the indoor environment in enclosures. Australian Standard AS 1668.2:1991 stipulates standards on mechanical ventilation systems. AS 1668.2-1991 'The use of mechanical ventilation and air-conditioning in buildings Part 2; Mechanical ventilation for acceptable indoor air quality' is the principal standard on the ventilation industry throughout Australia. It prescribes the minimum outdoor air requirements, the air discharge requirements and other specific ventilation requirements for enclosures. Supplemented to this are various codes of practice and guidance documents on the issue of thermal comfort. All these guidelines aim to create an ambient mechanically ventilated indoor environment.

AS 3666-1995 is another set of standards that is important for the issue of indoor air quality. It stipulates the standards on the control of micro-organisms in air-handling units and water systems. It sets out requirements on the materials, construction, location, inspection and clearing frequency of various components of these systems. The standards are enforced in building regulations, with accompanying guidelines on how to comply with the standards.

The Building Code of Australia regulates building practice in Australia through a performance-based approach. The Building Code of Australia provides guidelines on building designs leading to acceptable indoor air quality. It requires all occupied rooms should have adequate flow-through or cross-ventilation and acceptable air quality. This must be provided by natural ventilation from permanent, openable windows, doors or other devices with an aggregate openable size of not less

than 5% of the floor area of the room to be ventilated, or a mechanical ventilation system conforming to AS1668.2-1991 and AS3666-1995.

The effects of smoking on the quality of the indoor environment are well aware of by legislators and professional bodies. There are several legislative provisions specifically ban or regulate smoking in various areas including government buildings. Worksafe Australia released a national guidance document—the 'Guidance Note of Passive Smoking in Workplace' to tackle the problem of passive smoking in workplace in 1994. In New South Wales, a code of practice providing guidelines on passive smoking has also been issued under the Occupational Health and Safety Act.

The designs and the management practices of buildings have important influences on the indoor environment. Various professional bodies in Australia provide guidelines and advices to improve indoor air quality in buildings. Special guidance is given to building designers, building managers and other parties involved for the operation and the management of buildings. One of these guidelines is the 'Managing Indoor Air Quality' published by the Building Owners and Managers Association (BOMA) in 1994. The National Occupational Health and Safety Commission also publishes national exposure standards, guidelines and information booklets relevant to air quality in workplace environments.

2.3 Canada

2.3.1 Legislative Framework

It is the provincial government to make regulations for indoor air quality except in areas of Federal constitutions, like government buildings. Only indoor air

quality in residential buildings is legally governed under the National Building Code and there is no other indoor air quality legislation in Canada. Individual jurisdictions can adopt whichever part of the National Building Code to suit its own needs. Therefore regulations may vary with the jurisdictions.

2.3.2 Related Standards and Guidelines and Their Enforcements

Standards like ASHRAE, AIHA and ACGIH are widely adopted by the Federal and Provincial governments in setting related regulations. Under the Federal policy on improving indoor environment, buildings are required to be audited for indoor air quality from time to time. Moreover, the Federal Department of Labour has the authority to require building owners to adhere to those ASHRAE and ACGIH standards related to indoor air pollutants.

Since 1987, the Federal-Provincial Committee on Occupational Safety and Health has produced three sets of guidelines—the Residential Indoor Quality Guidelines, the Air Quality in Office Buildings: A Technical Guide and the Fungal Contamination of Public buildings: A Guide to Recognition and Management. These guidelines provide guidance to improve and monitor the indoor air quality in buildings in Canada. One of these guidelines—the Air Quality in Office Buildings: A Technical Guide attracts particular attentions. It is because in general office buildings are more susceptible to indoor environmental problems. The Federal Department of Labour has the authority to require building owners to follow this guideline.

The Canada Labour Code sets various prescribed standards, such as noise level standards and illumination standards to ensure the safety and health of

employees. The Code also empowers the Minister of Labour to prescribe standards for ventilation, air temperature and humidity. The Code also requires all business above certain size to form a Job Occupational Health and Safety Committee which is represented by workers. The Committee is empowered to consider and dispose of complaints related to indoor air quality problems. The Labour Canada produced a guideline on how IAQ investigations should be conducted in case a complaint is received. If the problem cannot be solved, the employee is allowed to bring the matter to the attentions of government authorities. Moreover, both the Federal and the Provincial labour inspectors are empowered to issue orders requiring building owners to remediate unacceptable conditions or even shut down a building until the problems are rectified. Failure to comply with the orders can result in fines and imprisonment.

The Federal Government of Canada conducts and sponsors researches for developing construction methods, codes of practice and analytical tools to ensure that standards on indoor environmental quality can be followed. Health Canada has published a number of pamphlets and reports about indoor air quality. It has also set up a Task Group on Indoor Air Quality in cooperation with the provinces and territories in Canada. The Canada Mortgage and Housing Corporation (CMHC) also has several publications on how to reduce and avoid too much humidity in homes and how to improve indoor air quality. Health Canada and CMHC are now working on a joint research project on air quality in homes. They are looking at how the chemicals and toxins produced by mould, bacteria and other contaminants can affect health.

2.3.3 Building Assessment Method

The Building Environmental Performance Assessment Criteria (BEPAC) system is used for assessing building performance in Canada. It was developed by Dr. Ray Cole and colleagues in Vancouver. BEPAC is modeled after the UK's BREEAM system. The evaluations of a building are based on a 'best practice approach' and the available standards which guide the designs and the operations of buildings. There are five major environmental categories, namely, ozone layer protection, environmental impact of energy use, indoor environmental quality, resource conservation and site and transportation. However, the method is limited to assess office buildings.

2.4 United Kingdom

There is no specific legislation to tackle IAQ standards in the United Kingdom (UK). However, some of the legislations, such as the health legislations, the building regulations and Control of Substances Hazardous to Health Regulation, have a bearing on the IAQ problems. The legislation of IAQ in UK adopts the European environmental legislations as some of the European Standards have been incorporated into the British Standards.

2.4.1 Health and Safety at Work Act 1974 and the Offices, Shops and Railway Premises Act 1963

These two Acts cover commercial buildings and require employers to provide a healthy and safe workplace to employees. Standards and guidelines specifically for air quality are not stipulated. However, there are requirements for ensuring the provisions of effective and suitable ventilations.

2.4.2 The Building Regulations

All building works are governed by the Building Regulations. Special requirements and guidelines for the control of toxic substances and the provision of an adequate means of ventilation are stipulated by the Regulations. Recommendations on how to achieve these requirements are also provided. The Building Regulations are referred to the British Standards.

2.4.3 The British Standards

There are specific provisions in the British Standards for ventilation systems and building management. There are guidelines on mechanical ventilation and air-conditioning systems in buildings, building maintenance management, control of condensation in buildings, design for natural ventilation, particulate air filters and general requirements for ventilation and testing. As mentioned before, some of the European Standards are incorporated into the British Standards.

2.4.4 Control of Substances Hazardous to Health Regulation

The Regulation aims at controlling hazardous materials in the workplace. It regulates the occupational exposure limits on a variety of organic and inorganic compounds which can cause potential health problems to human beings.

2.4.5 Other Regulations and Guidelines and Their Implementations

Regulations on IAQ are enforced by the local environmental health offices, the Department of Environment and other government departments. The environmental health offices enforce the Health and Safety at Work Act in offices, shops and restaurants. The Health and Safety Executive (HSE) is responsible for enforcing the

Act in other places. HSE also produced a set of guidelines for employers, building owners and managers on how to deal with sick building syndrome and passive smoking at work.

The Chartered Institute of Building Service Engineers publishes guidelines on the design, installation and maintenance of HVAC systems. The Heating and Ventilating Contractors Association also provides specifications on the maintenance of ventilation systems, air cleaning schedules and ways to avoid sick building syndrome.

Legionnaires' Disease is also a main issue. Various guidelines, such as the Information on Control of Legionnaires' Disease, Legionnaires' Disease - A Guide for Employers, The Approved Code of Practice and Guidance – 'Legionnaires' Disease: The Control of Legionella Bacteria in Water Systems' are issued by government bodies or other related professional bodies for providing guidance to tackle the problem.

2.4.6 Building Assessment Method

The Building Research Establishment launched the Building Research Establishment Environmental Assessment Method in 1991 for the labeling of environmental buildings. There are various criteria related to different aspects of the performance of buildings. Factors that affect the indoor environment include ventilation, passive smoking, humidity, lighting and thermal comfort.

2.5 United States

Various government departments and professional bodies act together to enhance a good indoor environment in buildings in the United States. This is achieved by setting regulations and guidelines on many building services systems. Researches are also carried out to develop effective means for improving indoor environmental conditions.

2.5.1 Environmental Protection Agency (EPA)

The EPA's Indoor Air Division supports indoor air programs in various regions in the United States. The IAQ research activities include IAQ monitoring, health effects assessments, exposure and risk assessments as well as IAQ controls. One of the studies is the Building Assessment Survey and Evaluation Program for Public and Commercial Buildings. The program is to establish databases on HVAC, building characteristics, environmental measurements and occupant perceptions on the indoor environment. Another study is the IAQ Source Management Strategy for A Large Building. It focuses on IAQ, product selections, building flush-out and ventilation strategies in the design and construction of buildings. Other researches cover issues like the microbiological screening of the IAQ and indoor emission standards. There are also researches for the development of low emitting and low impact construction materials for reducing indoor air pollution problems.

2.5.2 Occupational Safety and Health Administration (OSHA)

The OSHA is under a division of the U.S. Department of Labour. It sets regulations for safety and health in the workplace. It sets ventilation standards on general workplace and standards especially for the construction industry. Ventilation

criteria or standards are included in the OSHA Regulatory Codes for Job- or Task-Specific Worker Protection. In addition, many OSHA health standards include ventilation requirements. OSHA also issues technical guidelines for indoor air quality investigations. There are also guidelines specifically issued for the evaluation and investigation of office related health complaints.

2.5.3 American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE)

ASHRAE is a private professional organization with membership open to all nationalities. It establishes standards relating to buildings and IAQ specific issues. The ASHRAE 62-1989 and the ASHRAE 55-1992 provide guidelines for an acceptable indoor air quality.

2.5.4 Department of Energy (DOE)

DOE is actively involved in the development of voluntary consensus standards for ventilation systems in commercial and residential buildings. It works with the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) and the American National Standards Institute (ANSI). ASHRAE Standard 62-1989, 'Ventilation for Acceptable Indoor Air Quality,' specifies minimum ventilation rates and indoor air quality that will be acceptable to human occupants. DOE's IAQ projects strive to meet or exceed these specifications. Current research and development projects of DOE focus on improving commercial building airflow and ventilation measurement techniques and measuring and improving filter efficiency.

2.5.5 National Institute for Occupational Safety and Health (NIOSH)

The National Institute for Occupational Safety and Health (NIOSH) has two branches for handling IAQ issues. The Health Hazard Technical Assistance Branch responds to requests from individual buildings. The Industry Wide Studies Branch focuses on IAQ researches across buildings.

2.5.6 The Indoor Environment Department

The Indoor Environment Department conducts researches, technology developments and dissemination activities directed toward improving the health, comfort and energy efficiency of the indoor environment. The work focuses on reducing energy used for air conditioning and distribution of ventilated air in buildings. The department aims at improving indoor air quality and thermal comfort in buildings. The effects of the indoor environment on the health and productivitys of occupants are another areas of concern by the department. Researches are conducted to understand the effects of human exposures to environmental pollutants found in indoor and outdoor air.

The Commercial Building Ventilation & Indoor Environmental Quality (CBVIEQ) Group conducts researches on energy-efficient ventilation, pollutant transportation, particle control, health and productivity in commercial buildings. Some of the research topics include ventilation rates, indoor pollutant transportation, effectiveness of ventilation in controlling exposures to indoor pollutants, relationship of building and indoor environmental characteristics with sick building syndrome symptoms and worker productivity.

2.5.7 Building Assessment Method

The US Green Building Council (USGBC) launched a system designed specifically for use as a green labeling system for rating the performance of commercial buildings. The system is known as the Leadership in Energy and Environmental Design (LEED). The LEED system is now being implemented by the US Green Building Council, with strong support from US Government Agencies and private organizations. Indoor environmental quality is a main area of concern in this rating system. It covers monitoring on various indoor pollutants, ventilation effectiveness, lighting and thermal comfort which are prominent factors affecting the indoor environment.

2.6 Sweden

IAQ legislation in Sweden mainly focuses on ventilation systems. There are two major pieces of legislation on this aspect. They are the Ventilation and Air Quality Ordinance (ASF 1993: 5) and the Ordinance SFS (1991:1273).

2.6.1 Ventilation and Air Quality Ordinance (ASF 1993: 5)

The Ordinance deals with the requirements on the installation and maintenance of ventilation systems. It requires all occupational premises to be equipped with ventilation systems to remove air pollutants and to ensure an acceptable level of air quality. The Ordinance stipulates the cleaning devices and the indicator devices to measure the level of pollutants in the re-circulated air. Details of the directions under the Ordinance are set out in the complementary Code of Practice on Ventilation. This code of practice provides guidelines on the ventilation rates on different premises and standards on various chemical and biological air pollutants.

2.6.2 Ordinance SFS (1991:1273)

The Ordinance focuses on the technical and functional controls of ventilation systems. It requires building owners to be responsible for the functional control of ventilation systems before installation and regular checking afterwards. The Ordinance is complemented by the Code of Practice in Ventilation Air Duct Cleaning. This code of practice specifies duct cleaning methods, maximum levels of air movement and indoor air pollutants and the time intervals for checking with respect to different kind of buildings. It also sets the penalties for non-compliance with the rules.

2.6.3 Other Related Body

2.6.3.1 The Nordic Committee

The Nordic Committee sets up an indoor climate committee in 1987 to deal with IAQ problems. This indoor climate committee sets out strategies for the planning, construction, operation and maintenance of buildings for IAQ improvements.

2.7 Japan

2.7.1 The Law for Maintenance of Sanitation in Building

This law sets standards on the maintenance and management of air quality, supplied water, waste water, cleaning of buildings and pest controls. There are standards regulating the levels of indoor particulates, carbon monoxide, carbon dioxide, air temperature, humidity and air velocity. All the standards stipulated have to be met and regular checking for compliance is also required.

Guidance is also provided by the Environmental Health Bureau of the Ministry of Health and Welfare for ensuring proper enforcement of the Law. If the

standards are not met, the governor or mayor can order the building owners to rectify the problem. The building owners are subjected to fine or the building has to be closed if the order is not complied with.

2.7.2 Ministerial Ordinance of Sanitation in Buildings

This Ordinance sets standards on carbon monoxide concentration in indoor environment. It also stipulates procedures for measurement of suspended particulates, carbon monoxide, carbon dioxide, room temperature, relative humidity and air velocity in rooms of buildings.

2.7.3 Ministerial Ordinance of Sanitation in Offices

This Ordinance specifies the occupancy space for office workers and the required total openable window areas in relation to floor area. The requirements in room temperature, relative humidity, air velocity and limits on the concentration of suspended particulates are also covered in the Ordinance.

2.7.4 Related Guidelines

There are various guidelines issued by government departments and professional bodies which aim at reducing health complaints resulted from indoor environment. One of these guidelines is the Guideline for Prevention of Legionnaires' Disease. The Guideline recommends preventative measures on the selection of building materials and maintenance procedures. The Guidebook for Execution and Supervisory of Mechanical Equipment Work, the Common Specification of Mechanical Equipment Work and the Standard Chart of Mechanical Equipment Work are three main sets of guideline that aim at providing guidance to the design and

operation of ventilation systems in buildings to create an ambient indoor environment for occupants.

2.8 Singapore

Three government bodies are actively involved in improving indoor environmental conditions in Singapore. They are the Ministry of Environment, the Ministry of National Development and the Ministry of Labour.

2.8.1 Ministry of Environment

This Ministry has established the Technical Advisory Committee on IAQ. In late 1996, the Ministry published the Guideline for Good Indoor Air Quality in Office Premises. The Guideline focuses on improving air quality in air-conditioned office buildings. It sets standards on maximum concentrations of indoor air contaminants, air temperature, humidity and air movement. The Guideline also includes information about the health effects of various indoor air contaminants. It also provides recommendations on the design, construction, commissioning and operation stage of buildings on how to provide a good indoor environment for occupants. The Guideline is complemented by the specifications in the Singapore Code of Practice for Mechanical Ventilation and Air Conditioning in Buildings. A maintenance schedule and an audit in every two years for ventilation systems are also recommended.

2.8.2 Ministry of National Development

This Ministry is responsible for the administration of the Building Control Regulations. The Regulations cover the design and construction of buildings and

apply to all new and renovated buildings. It sets the design standards for HVAC systems.

2.8.3 Ministry of Labour

This Ministry is responsible for setting regulations and guidelines related to the health and safety of workers. In case health complaints related to IAQ of the workplace arise, the committee from the Ministry can carry out tests based on the procedures prepared by the Singapore Institute of Standards and Industrial Research (SISIR). The SISIR is responsible for preparing IAQ related standards and test methods in Singapore.

2.9 South Korea

Regulations and standards on indoor environment are stipulated in many pieces of laws and implemented by three major ministries in South Korea. They are the Ministry of Health and Welfare, the Ministry of Construction and Transportation and the Ministry of Environment.

2.9.1 Ministry of Health and Welfare

Two pieces of laws related to indoor environmental conditions are enforced by this Ministry. They are the Public Sanitary Law and the Public Health Law. The Public Sanitary Law covers IAQ standards in public facilities, including offices. The aim of this Law is to minimize the adverse health effects on the general public. The IAQ standards cover the levels of total suspended particulates, carbon monoxide, air temperature, relative humidity, illumination and air velocity. The Public Health Law is also important in tackling the problem of indoor pollutions. This Law was enacted

in 1996 which prohibits smoking in public places. Building owners are responsible for banning smoking inside buildings. They are also responsible for providing specific smoking areas inside or outside the building and these areas should be equipped with proper ventilation systems.

2.9.2 Ministry of Construction and Transportation

Two pieces of law related to indoor environmental conditions are enforced by this Ministry. They are the Architecture and Construction Law and the Underground Parking Law. The Architecture and Construction Law requires the use of ventilation systems in public facilities to maintain IAQ standards as prescribed in the Public Sanitary Law. The Underground Parking Law stipulates the air change requirements in large underground parking places.

2.9.3 Ministry of Environment

The Air Quality Guidelines for Underground Spaces is implemented by this Ministry. The Guideline regulates the air quality in underground spaces, including railways and arcades.

CHAPTER THREE

COMPARATIVE ANALYSIS WITH SITUATIONS IN HONG KONG

Measures for deal with indoor environmental issues in the developed countries and in those countries near Hong Kong have been reviewed in the previous chapter. This chapter first summarizes the situations in Hong Kong. It acts as the basis for comparisons between Hong Kong and other countries.

3.1 Hong Kong Situation

3.1.1 Legislation

There is no main legislation for the indoor air quality issues in Hong Kong at this moment. The general awareness of the issue has just increased in recent years. The issue may be regarded to be tackled to certain extent by a number of ordinances which are in fact not designed for this specific purpose. The existing related legislative measures as well as relevant government bodies involved in tackling indoor environmental quality problems could be summarized as follows:

3.1.1.1 Building (Planning) Regulation—Cap. 123

The Building (Planning) Regulation regulates building developments in Hong Kong through the Buildings Department. Approval of building plans and consent certificates are required before commencement of any building works. Section 30 and 31 of the Regulation specify the requirements for ventilation, especially natural ventilation to be provided to every room for habitation, offices or kitchen purposes. For offices that cannot comply with this requirement owing to restrictions on the

surrounding environment, provision of mechanical ventilation capable of supplying fresh air at a rate of not less than 5 changes of air per hour is stipulated under section 34 of the Regulation. If a modification of Section 30 or 31 has been granted to allow a deficiency in ventilation to be supplemented by mechanical means, the ventilation equipment must be in position and operation before an Occupational Permits is issued.

The Regulation not only regulates the design of ventilation systems for ensuring a proper air quality inside buildings but also tackles the maintenance aspect of ventilation systems. Under the Building (Ventilation Systems) Regulations, the owner of any building has a duty to appoint a registered ventilation contractor annually to inspect and certify that all dampers, filters and precipitators in such ventilation systems are in safe and efficient working order.

3.1.1.2 Factories and Industrial Undertakings Ordinance—Cap. 59

The Ordinance stipulates the requirements for ventilation in the workplace being regulated. It sets requirements for ensuring and maintaining circulation of fresh air to workplace and the removal of pollutants. It also requires the proprietor of the workplace to ensure the workplace is clean, with acceptable hygiene standard and lighting level to ensure the health of workers. Adequate measures taken to tackle for asbestos-containing materials, such as air monitoring, are also necessary to protect the health of workers.

3.1.1.3 Occupational Safety and Health Ordinance—Cap. 509

The Occupational Safety and Health Ordinance prepared by the Labour Department covers most workplace including offices. It stipulates the responsibilities of employers to provide a healthy and safe place for work. The Ordinance covers topics such as the use of chemicals and the use of Visual Displace Units which may affect the health of employees. It also requires employers to ensure that the workplace is adequately ventilated by fresh air and is sufficiently well lit by natural or artificial lighting. These are to ensure the safety and health of employees and other persons who work at the workplace. Improvement Notice and Suspension Notice may be served to employers who fail to comply with the requirements under the Ordinance. The employer is also prohibited to victimize employees who make complaints on health and safety issues.

3.1.1.4 Smoking (Public Health) Ordinance—Cap. 371

The problem of environmental tobacco smokes has been reduced by the enactment of the Ordinance. Several areas such as lifts and cinemas are designated non-smoking areas. However, office is not one of the designated areas under the Ordinance.

3.1.1.5 Public Health and Municipal Services Ordinance—Cap. 132

For the scheduled premises, adequate ventilation mechanism should be ensured in case natural ventilation is not sufficient before the operating licence is granted. Non-compliance can also result in revocation of the operating licence. Cinemas, factory canteens and restaurants are examples of the scheduled premises. The Ordinance regulates various components of the ventilation systems, such as air

intakes, exhausts and air filters, to ensure the proper functioning of the system. Maintenance requirements and the requirement for annual inspection of ventilation systems are also stipulated under the Ordinance. In case of non-compliance, penalties such as fine and imprisonment can be resulted.

3.1.1.6 Air Pollution Control Ordinance—Cap. 311

Under the regulations related to asbestos in this Ordinance, there are requirements for the proprietors of premises to investigate, maintain and remove all asbestos-containing materials. It also requires the use of registered consultants, supervisors, laboratories and contractors to carry out works related to asbestos-containing materials. This is important for ensuring the indoor air quality in premises. It prevents occupants from unacceptable exposures to asbestos which are hazardous to health.

3.1.2 Codes of Practice and Guidelines

Various codes of practice and guidelines were issued by various government departments and related bodies. Some of them are directly used to tackle the issue of indoor air pollutions while others are relevant to the issue. They are briefly described and summarized in this part.

3.1.2.1 Guidance Notes for the Management of Indoor Air Quality in Offices and Public Places

In September 2003, the Indoor Management Group of the Government of the Hong Kong Special Administrative Region issued the Guidance Notes for the

Management of Indoor Air Quality in Offices and Public Places (GN). The GN is not legally binding but a voluntary guideline.

The primary objective of this GN is to give background information and practical guidelines to building users enabling them to prevent indoor air quality problems and to solve problems promptly when they arise. The GN applies to buildings or totally enclosed areas served with mechanical ventilation and air conditioning systems for human comfort. It provides guidance on the design, operation and maintenance of buildings that may affect indoor air quality. It also covers the formulation of policies, procedures for investigation and mitigation of complaints related to indoor air quality problems.

3.1.2.2 Code of Practice for Energy Efficiency of Air Conditioning Installations

Air conditioning systems have prominent effects on the indoor environment especially in buildings with mechanical means of ventilation. This Code of Practice sets out the minimum design requirements on energy efficiency of air-conditioning installations. It is part of a set of comprehensive Building Energy Codes that address energy efficiency requirements on building services installations. Designers are encouraged to adopt a proactive approach to exceed the minimum requirements after taking into account the international standards and recommendations.

3.1.2.3 Practice Note on Ventilation of Common Corridor and Lift Lobbies in Buildings

The outbreak of Severe Acute Respiratory Syndrome (SARS) in 2003 arouses public concerns for a clean and healthy living environment and the importance of

good ventilation. This Practice Note is issued by the Buildings Department in January 2004 to supplement the ventilation requirements stipulated in the Buildings Ordinance. This Practice Note is issued to promote proper ventilation in common corridors and lift lobbies in buildings to enhance the indoor air quality.

Natural ventilation or mechanical ventilation in case natural ventilation is hindered is recommended to the stipulated areas at the building design stage. It is also recommended that fresh air intakes should be sufficient for the anticipated population at the stipulated areas. The air intake and exhaust points should be properly positioned to avoid contaminations. It also recommends proper maintenance and cleaning of ventilation systems.

3.1.2.4 Code of Practice for the Prevention of Legionnaires' Disease

In 1994, a Code of Practice for the Prevention of Legionnaires' Disease was issued. It provides guidelines for the design, installation, operation and maintenance of air-conditioning units and water systems, especially cooling towers and centralized hot water systems, for the effective control and prevention of Legionnaires' Disease.

Since March 1994, Legionnaires' Disease has been listed as a notifiable disease under the Quarantine and Prevention of Disease Ordinance (Cap. 141). Furthermore, the disease has been classified as a notifiable occupational disease since June 1999 under the Occupational Safety & Health Ordinance (Cap. 509) and the Employees' Compensation Ordinance (Cap. 282).

3.1.2.5 Practice Note for Managing Air Quality in Air-conditioned Public Transport Facilities

The Environmental Protection Department issued this Practice Note in 2003 and it covers public facilities such as buses and railways. This Practice Note provides guidelines to professionals on the management of air quality in air-conditioned buses and railway facilities operated in Hong Kong. It provides guidance for incorporating policies to achieve better air quality in these public facilities. Guidance is provided on air quality, design, operation, monitoring, inspection and maintenance requirements for the public facilities.

3.1.3 Government Efforts

There is no government department specifically set up for tackling issues of the indoor environment in Hong Kong. Government efforts to provide an ambient indoor environment can be observed in various departments which are reviewed in the following:

3.1.3.1 Electrical and Mechanical Services Department (EMSD)

The Electrical and Mechanical Services Department (EMSD) takes an active role in managing the indoor environment of government buildings. It designs and supervises the installation as well as the maintenance of all air-conditioning systems in government buildings. In 1994, the EMSD set up a dedicated team to conduct tests regularly on indoor air quality in government buildings. Recommendations for improvement are also provided when necessary. The test concerns about air temperature, relative humidity, carbon dioxide level, dust level and bacteria level inside the premises. (EMSD, 2003)

3.1.3.2 IAQ Management Program

To improve indoor air quality (IAQ) and promote public awareness of the importance of IAQ, the HKSAR Government has implemented an IAQ Management Program in October 2000. Guidance Notes for better management of IAQ in offices and public places were published. A voluntary IAQ Certification Scheme to assess IAQ of premises was introduced in September 2003. The Scheme covers offices and public places and there are two levels of IAQ objectives under the scheme- excellent or good (EPD, 2004). Offices that are served by mechanical ventilation and air conditioning systems may join the Certification Scheme. Building owners should engage a competent examiner to conduct IAQ measurements and take necessary remedies to rectify the building to such conditions that are in compliance with the requirements of either one of the IAQ objectives. The examiner can then issue the certificate which is to be registered in the Government Indoor Air Quality Information Centre for public access. Until February, 2004, most of the certificated buildings are government buildings and participation from the private sector is limited.

3.1.3.3 Labour Department

The Labour Department of the HKSAR also takes an active role in protecting the health of employees. Particular attentions have been given to office workers as the economy of Hong Kong is now based on the service industry. More and more people move from the manufacturing industry to the commercial sector and the number of people working in offices has increased. The Department has issued many guidelines for protecting the health of office workers. The most remarkable one is the Office Environment Series (OE 5/98). This series of guidelines help employers and employees to have simple health risk assessments about their working environment.

The assessments are in the simple checklist format. Recommendations for rectifications are also provided in some cases. This series covers matters related to lighting, ventilation, use of photocopiers and workstation design.

3.1.3.4 Architectural Services Department

The Architectural Services Department published various guidelines on the provisions of building services in buildings. It covers recommendations on specifications, monitoring and commissioning on air-conditioning and ventilation systems. These guidelines are especially relevant for government buildings which are mostly designed and maintained by the Department.

3.1.4 Private Sector Participations

The importance of the indoor environment has aroused concerns in recent decades. Many professional bodies are actively involved in promoting a better indoor environment to safeguard the health of occupants. Here highlights some of the schemes and guidance provided by these professional bodies.

3.1.4.1 Hong Kong Building Environmental Assessment Method (HK-BEAM)

The Hong Kong Building Environmental Assessment Method (HK-BEAM) is an assessment technique employed to evaluate the performance of a building with reference to environmental issues. It is developed by the Real Estate Developers Association of Hong Kong with the assistance of the Department of Building Services Engineering, The Hong Kong Polytechnic University, The Welsh School of Architecture, University of Wales College of Cardiff and ECD Energy and

Environment Limited, UK. The scheme is operated by the Center of Environmental Technology, Limited.

Specific assessment criteria for new offices, existing offices and residential buildings are stipulated under the HK-BEAM. The assessment methods were modeled on the Building Research Establishment Environmental Assessment Method in UK. Certification system is used for crediting buildings with good environmental performance. Reputation and marketing value of buildings may be increased by being certificated. However, participation to the scheme is wholly voluntary.

The scheme defines good practice criteria for a range of environmental issues relating to the design, operation, management and maintenance of buildings. Buildings are rated in four categories—'Excellent', 'Very Good', 'Good' and 'Fair' according to their performance. One of the main aims of the scheme is to improve the quality of the indoor environment and hence the health and well-being of the occupants (HK-BEAM, 1999). There are three main issues being considered in the assessment under the scheme and indoor environment is one of them. Indoor environmental issues cover areas like indoor air quality, contaminants and pollutants controls, indoor lighting, noise level as well as the operation and maintenance of building services systems.

3.1.4.2 Guide to the Management of Indoor Air Quality for Hotels in Hong Kong

The tourism industry is important to the economy of Hong Kong. It is important to provide an ambient accommodation environment to visitors and hence good indoor air quality in hotels is essential. This Guideline is developed by the Hong

Kong Polytechnic University. It provides a step by step indoor air quality management strategy for hotel owners on how to create and maintain a proper indoor environment. It covers areas like allocation of responsibilities, indoor air quality risk management, complaints investigations and on site surveys.

3.2 Comparative Analysis between Hong Kong and the Selected Overseas Countries

As people are more concerned about the impacts of the indoor environment, many regulations and guidelines are implemented to improve the indoor environment in overseas countries as discussed in the previous chapter. It is important for Hong Kong to be in pace with or even be more advanced than those countries in tacking indoor environmental pollution problems. This is because a good indoor environment is important for keeping the health of occupants and prevents reduction of productivity of workers. Therefore, promoting an ambient indoor environment is important for keeping the competitive power to attract investments to Hong Kong.

A comparative analysis is conducted which identifies the similarities and areas that Hong Kong is lag behind the selected countries in tackling the issue of indoor environmental problems. The results of the analysis are discussed in the following sections.

3.2.1 Similarities

Hong Kong and most of the selected overseas countries (except Japan and South Korea) do not have any ordinance or legislation specifically designed for governing the indoor environment. Regulatory controls are fragmented in many

pieces of ordinance and various parties are responsible for their enforcements. This may hinder the effectiveness of enforcement as the enforcement powers are scattered. It is because the indoor environment is affected by many elements in a building which are integrated and interdependent. Lack of uniform authority for regulatory controls makes it less effective in creating an ambient indoor environment.

Most of the regulations and guidelines in overseas countries and in Hong Kong concern about the ventilation and air handling systems. They refer to the ventilation standards stipulated in various standards like the Australian Standards, the ASHRAE Standards and the British Standards. The main objective of those regulations and guidelines is to ensure the ventilation systems meet the necessary fresh air supply and ventilate rate standards. However, proper maintenance of ventilation systems also induces great impacts on the indoor air quality, especially on the levels of pollutants indoors. The maintenance of air handling systems is mainly regulated by guidelines or codes of practices which may not have statutory enforcement power. Apart from the regulatory controls on ventilation systems, most of the efforts for promoting a good indoor environment are through guidelines and recommendations from various professional organizations and government departments. These are not legislative controls and their effectiveness is doubtful. One obvious example is the policy for banning smoking and the controls on passive smoking. Although smoking is prohibited in certain places in some of the studied countries and in Hong Kong, none of the studied place have legislations covering workplace as the designated place for banning smoking. Banning smoking in workplace is solely based on guidelines.

Hong Kong and the selected overseas countries mainly concern about indoor air quality. Less attention is paid to the lighting and noise levels inside buildings which also affect the environmental comfort perceived by occupants. The reasons may be that lighting level could easily be controlled by the occupants to suit their own user requirements depending on the activities. For example, people can easily add table lamps to increase the illuminance. The noise level indoor is mainly related to the human activities taking place indoors which makes guidelines and regulations difficult, if possible, to implement and enforce.

The management strategies of a building can also affect the indoor environment created. For example, quick and effective responses from the management company to complaints about the indoor environment can lessen the problem of adverse health effects on occupants. However, there is no guidance provided by the government on building management practice regarding the indoor environment. This is true in all the studied places including Hong Kong. Most of the existing guidelines are recommendations by professional bodies in which compliance is voluntary in nature but not legally binding.

3.2.2 Areas that Hong Kong is Lag behind

The similarities between Hong Kong and the overseas countries discussed above highlight the areas that are worth considering for improvements. This can result in advancements of Hong Kong compared with other overseas countries in promoting a good indoor environment. This advancement can increase the comparative advantage of Hong Kong. It is also of prominent importance to highlight the problem areas that Hong Kong is lag behind other countries. These are areas that attract

immediate efforts for improvements so as to retain the competitive power of Hong Kong. These areas are explored in this section.

In both Singapore and Canada, buildings are required to conduct indoor air quality audits from time to time as part of the indoor air quality management policies. The auditing policy encourages building owners to take an active role in managing an ambient indoor environment. In Canada, the Federal Department of Labour even has the authority to require building owners to adhere to standards and guidelines relating to indoor air pollutants. However, indoor air quality audits are not promoted by the government of Hong Kong.

Another advancement of Canada in promoting an ambient indoor environment is the requirement for all business above a certain size to form a Job Occupational Health and Safety Committee. The Committee is represented by workers. This Committee has the power to consider and dispose of complaints relating to indoor environment. The Committee can even decide to bring any unsolved matters to the attentions of government authorities. This policy provides more safeguards to employees and provides them with a channel to complain about the indoor environment. This policy is in fact very useful in promoting an ambient indoor environment. Usually it is the occupants that perceive discomforts about the indoor environment.

Japan and South Korea have specifically designed laws for regulating indoor environment. They are the Law of Maintenance of Sanitation in Building in Japan and the Public Sanitary Law in South Korea. A specifically designed law makes

enforcements to tackle indoor pollution problems more effective compare with the fragmented legislations in Hong Kong.

The last point that is worth considering is the availability of data about the indoor environmental conditions in buildings. In the United States, the Building Assessment Survey and Evaluation Program for Public and Commercial Buildings collects data for databases on HVAC, building characteristic, environmental measurements and even occupant perceptions on the indoor environment. A custom made database reflecting local situations is important for the formulation of relevant strategies and policies to solve indoor environmental problems. There is lack of incentive for developing such database in Hong Kong. Most of the guidelines and standards in Hong Kong are based on that of overseas countries, for example, the British Standards are commonly used as reference standards in building related matters in Hong Kong. The climate, environment as well as occupants' perceptions in Hong Kong are different from those in overseas countries. Parameters used in those standards should have been modified to take into account local conditions. Therefore, a database reflecting local conditions is essential for making the necessary modifications.

CHAPTER FOUR

LITERATURE REVIEW

In the previous two chapters, developments on the issue of indoor environment in Hong Kong and that in overseas countries are compared. The areas that Hong Kong is lag behind and should improve are also discussed. As mentioned before, open-plan offices are most susceptible to building related health complaints. In this chapter, the reasons for the popularity of open-plan offices are revealed. The rising concerns for building related health complaints and their causes are also discussed.

4.1 The Change from Traditional to Open-plan Offices

It is notable that open-plan type constitutes a great part of today's typical offices (Duffy & Tannis, 1993; Knight, 1995). Most offices in Hong Kong nowadays are open-plan offices too. There are many reasons for the popularity of open-plan offices in modern society. These reasons are reviewed in the following section.

The most likely reason is the change in working styles. Tong and Leaman (1993) observed that the growth in team work is one of the reasons for the popularity of open-plan offices. Communication is important in team work. Early work of Ives and Ferdinands (1974) reveals that employees believe that communication has improved after moving in open-plan offices. Davis (1984) tries to provide an explanation to this by offering that open-plan type facilitates interaction among organization members. It improves communication and increases office efficiency and productivity. Leaman (1992) adds that infrastructure costs can also be saved by making office wide, deep and open.

Davis (1984) reviews that the physical structure of office, especially the open-plan type, has received some fairly intensive researches. However, most of the studies do not support the view that open-plan office is superior to conventional closed office.

The arguments against open-plan offices are the various complaints received from its occupiers. Brookes and Kaplan (1972) report a decrease in organization member's satisfaction because of increased noise, loss of privacy, visual distractions and perceived reductions in efficiency after moving from a conventional to an open-plan office. Questionnaire and interview data from the work of Oldham and Brass (1979) further supports the deficiencies of open-plan offices. Their work indicates a significant decline on satisfaction and motivation among employees in open-plan offices. The U.S. Environmental Protection Agency (EPA, 1991) notices another issue that accompanying the popularity of open-plan office is the change from open windows to energy-efficient working environment in modern offices. Previous studies by Governo and Kavanagh (1997) and Turner and Myserson (2000) examine that the efforts to reduce energy cost results in the design and construction of completely sealed commercial building shells. They argue that this type of construction leads to indoor pollution problems and induces health complaints by occupants. A remarkable comment made by Leaman (1992) suggests that because the workspace layouts in open-plan offices tend to be relatively large in size, these offices need more services to temper and cool the air and artificially lit space away from windows. He observed that if these offices are not properly managed, they are much more likely to be unpleasant for occupants.

4.2 The Rise of Building Related Health Complaints

Health complaints associated with buildings have been reported since the early 1980s. It is not recognized by the World Health Organization (WHO) until 1982. The WHO (1983) suggests that those health complaints are resulted from a combination of physical, air quality and psychosocial parameters. They lead to a decline on the well-being of occupants.

Generally, the term 'problem building' is used to describe any buildings in which occupants are dissatisfied with the indoor environmental conditions (BSRIA, 2002). Building related health complaints may have a specific identifiable cause or no specific causal factor or factors can be identified. For many problem buildings, the causes may not be easily identified. The term 'sick building syndrome (SBS)' was introduced by the WHO in 1983. SBS is defined as an excess of work related irritations of skin and mucous membranes and other symptoms, including headache, fatigue, and difficulty concentrating, reported by workers in modern offices (WHO, 1983). The U.S. Environmental Protection Agency (1991) adds that SBS is the acute health and comfort effects that building occupants experience. SBS appears to be linked to the time spent in buildings but no specific illness or cause can be identified. Wayne (1995) puts forward the view that the complaints cannot be clinically diagnosed or medically verified. People report feeling better after leaving the building only makes solutions to verify the symptoms more difficult.

In contrast, some identified symptoms are diagnosable illnesses. Kreiss (1993) suggests that these illnesses should be described as 'building-related illnesses (BRI)' or 'specific building-related illnesses (SBRI)'. Wayne (1995) emphasizes that BRI is

dangerous to human health. Legionnaires' Disease and Pontiac Fever are the two best known BRI. Ridge (2001) proposes that these two diseases can be attributed directly to airborne building contaminants.

The WHO (WHO, 1983) identifies a list of symptoms find in sick buildings. The symptoms include stuffy, blocked, runny or itchy nose, dry throat, chest tightness, watering or itching eyes, headache, dry skin, lethargy, fatigue, dizziness, nausea and gastrointestinal symptoms. Wayne (1995) adds coughing and sneezing to the list. James and McDonald (2002) even include a less serious illness, the loss of concentration, to be linked to sick buildings.

4.3 Building Related Health Complaints in Hong Kong

Building related health problems have attracted attentions in recently years in Hong Kong. However, local studies in this area are limited. Poon (1991) concludes that the problem is only brought to public awareness by overseas experts during seminars and talks. Poon (1991) also states that the government of Hong Kong started to collect preliminary information on the problem of building related health complaints in 1988. A number of air quality studies and demonstrations were subsequently arranged in some government buildings. One of the studies was on Prince of Wales Hospital in February 1990. The results were generally satisfactory and the maintenance of the air-conditioning systems was proved to be of high quality (Poon, 1991). However, Poon (1991) argues that the severity of the problem cannot be identified unless a full scale survey is carried out.

Another study was conducted by the Healthy Building International Pty. Ltd. (HBI) (Now trading as ACVA Pacific Pty. Ltd.). Air quality studies in a number of prominent air-conditioned office buildings were carried out in Hong Kong in 1988. The findings of this study were quite alarming. It was found that air quality in office buildings in Hong Kong was as poor as buildings inspected by HBI in other parts of the world. HBI concluded that the major causes were inadequate ventilation and filtration and poor hygiene standards of air handling systems.

The problem of building related health complaints in Hong Kong can also be revealed by the Indoor Air Quality (IAQ) survey. The survey was commissioned by the Environmental Protection Department (EPD) and conducted between 1995 and 1997. Forty office buildings were covered in this survey. The survey reveals that 32% of the office buildings being surveyed may be identified as 'sick buildings'. It is argued that the main causes are the high occupancy density and poor operation and maintenance of mechanical and air-conditioning systems (EPD, 2004).

The survey conducted by The Occupational Safety and Health Council (OSHC) and the Chinese University of Hong Kong (CUHK) further points out the seriousness of building related health complaints in Hong Kong. The survey covered sixty offices in 15 districts in Hong Kong. It was conducted between 1999 and 2001. The study reveals that among the 1477 office workers who completed the survey, over 60% claimed that they suffered from one or more of the following symptoms after they started working in their offices: runny nose, blocked nose, sneezing, itchy nose and itchy eyes. Over one third of the patients claimed that the symptoms were aggravated while at work. Half of the sufferers reported improvements during weekends or

holidays (OSHC, 2001). It is therefore suggested that office management should examine and clean air vents and ducts regularly to ensure the air ventilation systems are clean. Fresh air should not be drawn from polluted sites and cooling towers should also be cleaned regularly (OSHC, 2001).

4.4 Possible Causes for Building Related Health Complaints

Since SBS is recognized by the WHO, concerns have been directed towards identifying the causes and thus the ways of eliminating those health complaints. Despite the large number of studies carried out in the past decades, no single cause has been identified and in fact few investigations have conclusively proven the causes (Poon, 1991). Previous studies have identified some causes that are possible to result in building related health complaints. They are physical or indoor environmental factors, lack of personal control to the indoor environment, building management related factors as well as personal and occupational factors. These factors are reviewed in this section:

4.4.1 Physical Factors

4.4.1.1 Air-conditioning System

Air-conditioning systems are commonly installed in modern offices. It is especially true for the open-plan type as most windows for ventilation are located along the perimeters of buildings. The central part can hardly have enough natural ventilation to keep a pleasant working environment. Therefore artificial ventilation systems are installed to improve the situation. However, air-conditioned environment creates problems. According to Lush (1991), lack of fresh air, stuffiness and too much air movement occur in air-conditioned buildings. These affect the well-being of

occupants. Sykes (1988) and Rostron (1997) postulate that building related symptoms are more likely to occur in air-conditioned buildings than in naturally ventilated ones. The National Institute for Occupational Safety and Health (NIOSH) published the results of a study on 356 buildings with health complaints by staff in 1989. NIOSH (1989) concludes that 52% of the health complaints in buildings are the result of inadequate ventilation and dirty contaminated air-conditioning systems. It seems that air-conditioning systems can create paramount effects on the physical environment inside buildings. Air-conditioned environment can cause adverse health effects on occupants. However, the study by Niven et al. (2000) found that well designed air-conditioned buildings can out perform the naturally ventilated environment.

Improper setting of air temperature may create problems. Researches by Clausen et al (1993) and Fang et al (1998) prove a strong correlation between air temperature and the prevalence of building related health symptoms. Fang et al (1998) argue that high air temperature influences the perceptions of indoor air quality. Warmth that causes stuffiness is associated with health complaints. A study by Kaplan and Aronoff (1996) put forward the view that computer equipment deteriorates the physical environment in offices which affects the health of people. They argue that the use of computers and printers generate heat which may overload the air-conditioning systems. Offices then become warm and stuffy. BSRIA (2002) points out that usually high air temperature can cause chest tightness, headache, lethargy, ocular and nasal complaints. Niven et al. (2000) report that asymmetric horizontal air temperature may cause symptoms of dry throat and lethargy.

The metabolic rate of human body also affects the perceptions of air temperature. Pöllman (1994) puts forward the view that changes in indoor air temperature during working day may be beneficial because the body's metabolic rate rises during the day. He suggests that warmer air temperature in the morning and cooler air temperature in the afternoon may be an effective way to reduce some of the discomforts. His view is partly supported by a later study by Ooi et al. in 1998. The study reports that 25% of the health complaints reported occurred in the afternoon. However, this study also reveals that most complaints do not notice a trend in time. Ooi et al. (1998) therefore protest that there is no obvious relationship between the prevalence of symptoms and the fluctuations in air temperature, and even relative humidity or air movement beyond recommended levels.

Sufficient ventilation provided by air-conditioning systems to keep the indoor environment a healthy place for occupants is essential. Ventilation should aim at providing good quality indoor air to occupants. The needs for individual control should be recognized and the correct operation of energy and indoor air quality systems should also be ensured. BSRIA (2002) points out that the inflexibility of ventilation systems to cope with changes in need causes health complaints. The reason is that the ventilation systems in a building usually remain as originally designed even the number of occupants there increases. Early work of Jaakkola and Heinonen (1987) illustrates that a decrease in the ventilation rate causes building related health complaints. This is argued by Menzies et al. (1990) who report that an increase in the ventilation rate can also cause health complaints. It is therefore important to keep a suitable ventilation rate for an ambient environment. The ventilation rate should be decided by considering all relevant factors inside a building.

The European Commission (1996) indicates that the ventilation rate required to keep a place fresh and healthy depends on the number of occupants, the volume of the building and the activities being carried out in that place.

Air-conditioning systems also affect the relative humidity of the indoor environment. Research by Sundell (1994) shows that lower than 35% of relative humidity over a long period of time causes the tendency for feeling dryness in eyes, nose and throat. However, this cannot be interpreted as the problem can be released by keeping a high relative humidity indoors. It is because high relative humidity provides an ideal living environment for micro-organisms such as bacteria and fungi. These micro-organisms may be harmful to the health of occupants. They can also get into buildings by penetrating the ventilation systems or by the occupants. These harmful micro-organisms are being re-circulated in the occupied space by ventilation systems. As a result, health complaints occur.

4.4.1.2 Lighting

Artificial lighting is used in most modern office buildings especially in the open-plan type. It is because windows are commonly located along the perimeter of the building in open-plan offices. Natural daylight is not sufficient for the wide and deep offices. The quantity of light or illuminance should be matched with the needs of the occupants. Special care should be taken to ensure a suitable lighting level for occupants. This is especially important for buildings with central lighting systems as occupants can hardly have control on the lighting level in these buildings. Glare which causes discomforts and distortions should be avoided. BSRIA (2002) points out that inappropriate lighting level can cause ocular or headache complaints.

The use of computer gains its popularity in the past two decades due to the introduction of personal computers in early 1980s. Particular attention to lighting should be addressed in areas where Visual Display Units are used. Computer users often complain about inappropriate lighting levels. The primary causes of complaints are high-luminance reflections from screens and imbalance in the luminance of surfaces regularly looked at by the worker (CIBSE 1993). It is common that computer users move his or her eyes between the screen and the paper. Brazier (1993) observes that if the office is lit by one light source, either the level required to illuminate the paper will cause the computer screen's images to pale or the adequate level for the computer screen will strain the worker's eyes when scanning the page.

4.4.1.3. Noise

Open-plan offices usually have a large number of workers and a few partitions. Boerstraa and Leyten (1997) state that these cause a high level of noise with distracting contents. For example, the clicking sound of keyboards creates undesirable background noise. BSRIA (2002) further points out that the use of printers and photocopiers produces noise which can result in neurological complaints and unwanted distractions. Textile surfaces such as carpets are commonly used to reduce noise. However, if the carpets are not properly maintained, they become another source of health complaints. It is because dusty carpets are the perfect place for the growth of harmful viruses.

Rostron (1997) advocates that low frequency noise can have direct link with sick building symptoms but high frequency ones are inversely related. The work of Burt (1996) on infrasound-related sick building symptoms also supports this view.

Burt (1996) observes that complaints about infrasound-related sick building symptoms increase in recent years. The causes of the complaints can be explained by the combination of tight sealing of modern buildings and ventilation noise, which amplify the low frequency sound. According to Burt (1996), the infrasound causes allergic type responses in human bodies.

The space arrangement inside open-plan office also has great impacts on the noise generated. Leaman (1992) reports that a study by the Building Use Studies Ltd on open-plan offices found that 60% of the staff were sitting directly next to a primary circulation route, tea-points, photocopiers or toilets. To these staff, noise generated from the nearby is not directly associated with their immediate work tasks. This noise is perceived as disturbance by the staff.

4.4.2 Chemical Factors

4.4.2.1 Volatile Organic Compounds (VOCs) and Gaseous Contaminates

Both volatile organic compounds (VOCs) and gaseous contaminates are air pollutants. They are released from building synthetic materials and office equipment. Arnold (2001) and Guidry (2002) believe that carpets, plywood and adhesives used in buildings continuously release some chemicals including VOCs into the air. Guidry (2002) also suggests that photocopying machines and laser printers release a significant amount of VOCs and ozone into the air. In air-conditioned buildings, these pollutants have no way of escape but being spread by the air-conditioning units through re-circulation of air. This results in poor indoor air quality.

Smoking makes the situation even worse. Tobacco smoking emits many toxic and carcinogenic pollutants in the air. The most dangerous one is carbon monoxide, a gaseous contaminate that affects the oxygen carrying capacity of red blood cells. Exposure to carbon monoxide causes dizziness and even a very low concentration can cause death. However, offices in Hong Kong are not protected by any ordinance from environmental tobacco smoke.

4.4.3 Lack of Occupant Control on the Environment

Personal control to the environmental conditions allows workers to adjust the conditions according to their own needs. It is an important psychological factor. Boerstraa and Leyten (1997) note that a high level of perceived control on the environment can improve the health and well-being of occupants. However, personal control is difficult to achieve in large space like open-plan offices. These offices are usually incorporated with central control systems. They rarely offer any adjustments on the ventilation rate, lighting level or other parameters for its occupants on an individual basis. Management companies believe that central control systems can deliver an environment with acceptable quality to occupants. However, the validity of this belief is questioned by the results of the research conducted by Bromley et al. in 1993.

However, Bordass et al. (1993) disagree that lack of individual control devices for adjusting the indoor environmental conditions is the cause of health complaints. They propose that perceived control tend to come from systems which can respond quickly and effectively when people find conditions unsatisfactory rather than from a

particular individual control device. Too much control by individual can result in insolvable conflicts and make things even worse.

4.4.4 Building Management Related Factors

As reviewed before, most building related health problems can only be discovered through complaints make by the occupants rather than from direct clinical diagnosis. If those complaints are ignored by the management company and no response is taken to tackle the problem, the problem is worsened and occupants are also affected psychologically. Leaman (1995) argues that perception of control increases where there is a 'rapid response environment'. Such environment is created by a management system that responds quickly and positively to occupants' complaints of discomforts and malfunctions of any building systems. This highlights the important role of building management to solve the problem of building related symptoms.

BSRIA (2002) points out that the importance of proper and regular cleaning is often being overlooked by management companies. In fact, this is a major cause of health complaints. Cleaning is important for the removal of particulates. It is extremely important that carpets, which are commonly used in most offices, should be cleaned regularly to remove dusts and bacteria. In places where office rents are high, like Hong Kong, companies usually arrange the office equipment for the most effective use of space. It creates difficulties for cleaning those carpeted areas where in fact collect dirt and dusts. This results in raising levels of airborne particulates which deteriorate the indoor environment, especially the air quality.

Guidry (2002) points out that inadequate maintenance of building services systems is another cause for indoor pollution problems. Inadequate maintenance causes air filters in the heating, ventilation and air conditioning (HVAC) systems to be contaminated. The ducts are dirty or there are clogged drains in the systems. The problem may be worsened if the systems are inoperable or inaccessible for maintenance.

The growth of team-based working practice causes another problem. Tong and Leaman (1993) observe that during re-planning of workspace, the effects of space arrangement on the indoor environment are often ignored by the professional bodies involved, such as the facilities managers.

4.4.5 Personal and Occupational Factors

Some researchers argue that it is unfair to conclude that health complaints are solely due to problems in the indoor environment or poor building management strategies. The personal characteristics of the occupants and the working practice of the organizations where the sufferers are working in also contribute to health complaints. However, these areas are outside the professional competence of architects, surveyors and engineers. Thus they are only highlighted briefly in this section to raise the awareness of these factors.

A study by Ooi et al. (1998) finds that female is more sensitive than their male counterparts to building related health complaints. Job nature also affects the prevalence of symptoms. Symptoms appear more likely among clerical staff with rather boring activities. BSRIA (2002) tries to offer an explanation by claiming that it

is difficult for people with repetitive works to concentrate for a long period of time. Their concentrations wander and a greater examination of the environment may take place. These people are therefore far more aware of any minor changes in the environmental conditions and more health complaints may be reported by them. However, Niven et al. (2000) point out that it is difficult to determine whether the higher sensitivity by female clerical or secretarial workers is due to the work status and sex or due to the poorer working environments as they are usually sitting in the more crowded and least favourable positions.

Occupational stress is another area of concern. Researches undertaken by BSRIA suggest that there is a significant link between stress and the incidence of building-related sickness. (BSRIA, 2002) It may be this psychological factor that attribute to health complaints rather than the physical characteristics of the building that people work inside. However, BSRIA (2002) argues that whether stress is causative to health complaints or whether health complaints cause stress is difficult to rationalize. One of the well-noted cases was that several employees sued and claimed that their building made them sick. The lawsuit ultimately failed as no building-related cause could be proved. It was claimed that the symptoms in many of the employees are mental or emotional in origin. (Babura v S. E. W. Investors, No. 90-CA-10594 D. C. Super. 1995)

4.5 Effects of Building Related Health Complaints

The most obvious effect to those occupants being affected by the indoor environment while at work is that their productivities are reduced. Workers cannot perform well in conditions where they suffer health problems. They may even need

sick leaves. Leaman (1995) advocates that people reporting discomforts and dissatisfactions at work have their productivity affected because the uncomfortable environment affects their ability to perform their work properly. Kaplan and Aronoff (1996) agree that comfort and environmental control have direct impacts on human performance. Study in Hong Kong by the Occupational Safety and Health Council and the Chinese University of Hong Kong (2001) provides an empirical support for this argument. Office workers in this study complained about decrease in work performance resulted form health problems they suffered when working in poor working environment. However, there is still lack of data about the financial impacts associated with this loss in productivity. Apart from reduction in productivity of workers, the building itself is also affected by those health complaints. Ilozor et al. (2001) point out that the value of the property is affected by the health complaints received from its occupants. This is understandable as the reputation of the building is being affect by perceived as 'being sick'.

4.6 Conclusion

Conclusively, the possible causes for building related health complaints are controversial. It is an interaction of many factors including physical and psychological ones that cause the complaints. Previous studies failed to identify which one is the critical factor. Some of the possible causes for building related health complaints can be tackled by the construction and property professionals. These include the physical indoor environmental conditions, the degree of personal control and the property management strategies. It is therefore proposed that buildings with well designed building services systems can create a good indoor environment for occupants. Proper management policies that emphasize on the importance of a clean and healthy

environment can also alleviate the prevalence of health complaints. Moreover, prompt and proper responses given by management companies to health complaints from occupants are also important. This can help in creating the perceptions of control on the environmental conditions.

CHAPTER FIVE

METHODOLOGY

An empirical study was conducted in open-plan offices in Hong Kong. The empirical study is to validate the effects of the indoor environment and the perceptions of personal control on the indoor environment on the health of occupants. In this chapter, the methodology employed and the rationale behind as well as the method of data analysis for this research are presented and discussed.

5.1 Research Design

This study composed of two stages. Both stages used face to face questionnaire survey as the instrument for collecting the data required. Face to face interview was used rather than posting or distributing the self-administered questionnaires to the target group. It is because the former one is more efficient and effective. Postal method by sending the questionnaire to the office workers and asking them to send back the completed form was not desirable. It is likely that the response rate would be affected by the convenience of the office workers to postal offices. Like the case of directly distributing the questionnaires to the workers, approval and co-operation from the management companies of the target buildings would be required. This would be the most difficult and time-consuming stage and disapprovals would reduce the sample available. Moreover, if the questionnaires were distributed to the workers and the workers were asked to complete it in offices, the responses given by the workers would more likely be affected by their colleagues.

The first part of this study was to find out the list of building related symptoms perceived by office workers in Hong Kong. This was achieved by using a simple open-ended question. Workers were asked to list out those health symptoms which they had perceived when they were working in the office but were reduced when they left the building. Different investigations carried out in different countries contributed different lists of building related symptoms. The two commonly used questionnaires, the Office Environment Survey questionnaire and the MM questionnaire, also include different symptoms in the lists. The Office Environment Survey questionnaire was developed by Wilson and Hedge in 1987 and is used widely in UK. The MM questionnaire was developed by Andersson et. al in 1993 and is used in Europe. The purpose of this part of the study was to find out the health symptoms that office workers perceived in typical office buildings in Hong Kong. It was an important step as it could give a more valid list of symptoms reflecting the situation specific to Hong Kong. A copy of the questionnaire is shown in Appendix One.

The second part of this research was to make use of the findings in Part One to investigate qualitatively the relationship between the symptoms perceived and the indoor environmental conditions. The list of symptoms collected in Part One was employed as a question in the questionnaire used in Part Two. Only information that was important for the analysis was asked in this part. This was to reduce the sensitivities of the required data and encourage responses. The questions were based on literatures from previous studies which were proved to be related to the perceptions of building health symptoms. Same as Part One, data required in this part was also collected by face to face interviews using the standardized questionnaires. A copy of the questionnaire is shown in Appendix Two.

5.2 Sample Selection for Part One

As most of the office buildings are situated in Central, Wanchai, Admiralty, Causeway Bay and Tsim Sha Tsui districts in Hong Kong, the target group was chosen from these districts.

5.3 Data Collection for Part One

The interviews were carried out during evening hours when most office workers had completed their work of the day. The target group was those pass-by office workers near the Mass Transit Railway (MTR) stations at Central, Wanchai, Admiralty and Causeway Bay. The interviews were conducted in four successive working days from Monday to Thursday in early January 2004. The interviewer chose to wait for those potential respondents near the MTR stations instead of near office buildings. It was because the former could allow occupants from different office buildings within the district to be interviewed. Bias due to the process of sample selection could then be minimized and a broader view about the symptoms perceived by general office workers could be obtained. If a particular building was chosen instead, it was likely that the responses collected only reflected the situation of that particular building. Before the interview, a simple question about whether the potential respondent was working in an open-plan office was asked. This was to ensure that he/she was a suitable member of the target group. The number of male and female respondents was kept to be similar so that the views from both genders were collected.

The interviews were carried out in the evenings as these were the time that most office workers had completed their work of the day and left the office buildings.

At that moment, they were more likely to complain about discomforts. It was because they might have suffered from those health problems for a whole day while they were working. Moreover this time slot was more suitable than the time before they start working in the morning. In the morning, they would be hurry to work and less willing to stay behind for the interviews. This would highly reduce the response rate. In addition, the office workers might not be able to recall health problems after a night of sleep if the interviews were conducted in the morning.

A total of 50 questionnaires were collected in these four districts and similar number of questionnaires was collected from each district. It was found that most workers complain about fatigue as one of the symptoms. This could be explained by the time of the interviews as the workers were tired after a day's work. This bias due to the time slot problem was acceptable because this part of the research was to collect the list of health complaints by the general office workers. The frequency of any kind of complaints would not affect the validity of the results. There was no pre-decided number of respondents needed for this part of the study. The interviews ended when the responses showed a steady trend that most of the complaints by the respondents were expressed and collected.

5.4 Questionnaire Design for Part Two

The design of the questionnaire was based on the questionnaires used in similar studies in other countries with modifications to suit the situations in Hong Kong. Literatures on the design of questionnaire for office environment survey and sick building syndrome were also consulted.

The British Medical Association conducted a study on building related health complaints by using questionnaires in Singapore in 1998. (Ooi et al., 1998) The questionnaire used in this study includes sex, age and nature of work as the basic information. Evaluations by occupants about the thermal comfort, noise and lighting levels in the workplace were also collected by the questionnaire. Niven et al. (2000) apply similar approach for the design of the questionnaire used for a study on healthy and unhealthy buildings. Factors like air temperature, relative humidity, pollutant, lighting and noise level were included. As mentioned in the Literature Review chapter, lack of personal control on the environment and building management strategies also affect the health of occupants. The nature of the job and the gender of the respondents can also affect the number health complaints reported. Therefore, information about the degree of personal control on the working environment as well as the gender and job nature of the respondents is collected. This was achieved by including necessary questions in the questionnaire. For the purpose of this study, if occupants can complain about environmental discomforts to relevant parties, like the management company, and satisfactory responses to rectify the problem is given within a reasonable time, it is regarded that personal control on the environment is available.

Questions for evaluating the indoor environment were included in the questionnaire. One objective of this study is to investigate the effects of the indoor environment on the health of occupants. Therefore, it was necessary to include questions to collect information about the perceptions on the indoor environment by the occupants. However, unlike questionnaires used in foreign countries which have two separate evaluations about the indoor environmental conditions in summer and

winter, only one evaluation was used in this study. It was because the climatic conditions in Hong Kong do not vary a lot between summer and winter compared with those in countries like UK and Europe. The differences in air temperature and relative humidity between summer and winter are not very great in Hong Kong. Building services systems used for warming up rooms, which is the major influence on the indoor environment in winter, is less likely to be incorporated in buildings in Hong Kong.

Although the list of building related health symptoms was collected in Part One, the way of expressing the symptoms was referred to literatures on similar topics. The UK Office Environment Survey questionnaire includes 'dry eyes' as a separate symptom, while 'watering' and 'itching' eyes are combined to form another symptom. However, the MM questionnaire has 'itching eyes' combined with various eye symptoms such as irritating or burning eyes in the questionnaire. Moreover, Raw et al. (1994) states that questionnaires used in Europe tend to include a symptom 'heavy headness'. However, there is no such equivalent in questionnaires used in UK. Skin symptoms are also commonly included in European SBS questionnaires but not in UK questionnaires. A study by Raw et al. (1994) reveals that the prevalence of 'watering eyes' is increased to a much greater extent by the addition of 'itching eyes' than is the prevalence of 'dry eyes'. So in this questionnaire, 'itching eyes' is combined with 'watering eyes' as a symptom while 'dry eyes' is another separate symptom. Raw et al. (1994) reveal that the inclusion of 'feeling heavy headed' does not affect the prevalence of 'headache' or 'lethargy'. Therefore, 'feeling heavy headed' is not included in the symptom list in the questionnaire of Part Two. This is also validated

by the data collected from Part One as only 6% identified ‘feeling heavy headed’ as one of the symptom. At the same time, they also complained about headache.

The guideline on questionnaire design for the study of sick building syndrome prepared by the Building Research Establishment in 1995 suggests that a symptom should be recorded if the respondent has perceived more than two episodes of it in the past twelve months. This may tackle the effects of seasonal variations for the perceptions of the symptom. However, this criterion was not used in this study because of two main reasons. Firstly, seasonal variation is not very big in Hong Kong. Secondly, if the criterion was applied, a recall period of twelve months was needed. It would be very unlike that the respondent can recall if he/she had a particular symptom twelve months ago. It was because most of the symptoms identified are not serious illnesses and the sufferers might not have consulted a doctor.

A question was necessary to validate that the perceived symptoms were related to the working environment in offices. There are three main options for this question. The first one is used in the Office Environment Survey which asks ‘please indicate if the symptom is better on days away from the office’. The second option is from the questionnaire used by Zweer et al. in 1990. It is phased as ‘please indicate if you experience the symptom less when you are at home’. The last one appears in the MM questionnaire which states ‘please indicate if you believe the symptom is due to your office environment’.

A study carried out by Roys et al. (1994) discovers that there is no significant difference between the three options of building-relatedness questions in term of the

effect on the total number of symptoms reported by a respondent. It is therefore better to use the most direct one, i.e. the first option. For the second option, it is difficult to validate whether the symptom is related to office environment as the home environment of different people is different. In Hong Kong, people usually live in small flats and the environment in their homes is not necessarily better than that in their working place. For the third option, the question is a bit ambiguous to the respondents because they need to make their own judgment. The respondents may not have the necessary information and knowledge to make the judgments.

Apart from identifying the number of symptoms perceived by the occupants, the questionnaire was also designed to collect information about the frequency and intensity of occurrence of each symptom. This allowed a more comprehensive comparison. The frequency scale used in the MM questionnaire has three options, namely 'often', 'sometimes' and 'never'. Other questionnaires used six options ranging from 'every working day' to 'at least twice a year' in the frequency scales. The frequency scale suggested by Raw (1995) uses five options that are mutually exclusive and all possible frequencies falls into one of options. However, all these frequency scales can only reflect the frequency of occurrence of symptoms. There are no implications on the seriousness of the symptoms as perceived by the respondents. It is not a fair comparison by using the frequency of occurrence of symptoms only. For example, occupants in one building complain a symptom to be perceived frequently. Occupants in another building perceive the same symptom less frequently but perceive it to be more serious. It is not necessary that the first building is with a worse indoor environment. The intensity of the perceived symptoms should be included for comparison. A modification is thus required to the options in the

frequency scale. Based on the suggestion by Burt (1995), respondents were asked to rate the frequency and intensity of occurrence for each of the perceived symptom. A five-point Likert scale ranging from 1(little/seldom) to 5(a lot/always) was used. This scale recorded both the intensity of occurrence (ranged from little to a lot) and the frequency of occurrence (ranged from seldom to always) of each symptom.

Regarding the layout of the questionnaire, two major options are usually used in previous studies, especially for recording the symptoms perceived. They are the table form and the separate form. In the separate form, perceptions on every symptom are asked by using separate formal questions. In the table form, a table is used for recording the perceived symptoms. Roys et al. (1994) argues that there may be a tendency for people to respond in a similar manner to a number of questions if they are in the same format and relative position on the page, as in the table form. Their study reveals that separate questions give a more accurate picture of the frequency of occurrence of each symptom. It is because each question is less likely to be affected by the previous question as in the table form. However, the disadvantages of the separate form are that the questionnaire takes up a larger space and the respondents are required to take longer time to complete it. As the questionnaire used in this study is not very long, the disadvantages of the separate form are not serious problems. Therefore, separate formal questions were used to record the frequency and intensity of occurrence of each symptom in the questionnaire.

Based on the above discussions, the questionnaire for Part Two was divided into four main parts. The first part focuses on the respondents' perceptions on the indoor environmental conditions where they were working in. The second part

focuses on the degree of personal control that the respondents perceived on the environmental conditions. The third part records the frequency and intensity of occurrence of symptoms that the respondents had perceived when working in their offices. This section also includes a question about whether the productivities of the respondents were affected by those perceived symptoms. The last part is to collect information on confounding factors. This information was necessary for adjusting the data collected from the previous three parts so that a more reliable analysis can be conducted.

5.5 Pilot Study

The questionnaire used in Part Two was more complicated than that used in Part One. A pilot study was therefore conducted on the questionnaire used in Part Two. Interviews were carried out in one office building in Central. About twenty questionnaires were collected for analysis to check if the questionnaire was well-designed to achieve the objectives and collect the required data. This process also trained the interviewer's skills on expressing the questions and interpreting the responses. The questionnaire was amended based on the comments and responses in the pilot study. The time required for completing the interview was also noted so as to estimate the time required for the interview. This was important because if the potential respondents were told about the time needed for the interview, they would be more willing to help provided that the required time was not too long. The questionnaire was not time-consuming as most respondents could complete it within 5 minutes.

5.6 Sample Selection for Part Two

The sample was carefully selected to avoid unnecessary bias and be representative enough for validating the hypothesis. As pointed out in the previous chapter, the causes of health complaints are controversial. The causes can be resulted from improper design, operation and maintenance of building services systems that create a poor indoor environment for occupant. The building management strategies also play an important role on creating or preventing those health complaints.

Based on the above, it was assumed that buildings with good indoor environment could alleviate building related health problems. A good indoor environment can be created by installing proper building services systems. The systems should also be well maintained by proper management strategies. The sample chosen were based on these criteria.

The sample was selected from office buildings certificated under the Hong Kong Building Environmental Assessment Method (HK-BEAM) for office buildings version 2/96R. The 2/96R version is especially for assessing the performance of existing air-conditioned offices in Hong Kong. The assessments cover the operation, maintenance and management aspects of buildings but not deal with the design and construction stage. Using buildings certificated under the 1/96R version may give a broader view as the 1/96R version includes the building design and construction stage for assessment. However, due to the limited number of buildings certificated under the 1/96R version, this was not chosen. Despite a new version, the 2003 version has been released; the number of buildings certificated under this version is even more limited. Many buildings are still undergoing the assessment process under this new

version at this moment. It is unable to identify suitable buildings certificated under this new version for study at this moment, therefore, this new version is also not chosen for investigation.

One objective of the HK-BEAM scheme is to promote a good quality of indoor environment in office buildings. Indoor issues include all aspects of a building including design, operation and fitting out. Thermal comfort, air quality, lighting and the avoidance of use of hazardous materials are considered for assessment (HK-BEAM, 1999). The assessment of buildings was in a form of checklist. Buildings are rated with either 'Excellent', 'Very Good', 'Good' or 'Fair' based on the number of credits achieved.

Only the overall ratings of the certificated buildings could be obtained for this study because the required information is sensitive. It is noted that out of the 63 credits on the checklist, 25 credits (about 40%) are directly related to the indoor environmental issues. 20 credits out of the remaining 38 credits are indirectly related or can affect the indoor environment of the office buildings, making a total of over 70%. It was therefore reasonable to use those certificated buildings as the sample for investigations. Further considerations were taken during the sample selection process to take into account those unrelated credits. On-site visits and plan analysis were carried out to identify buildings with similar facilities that contribute to the credits under the checklist which are unrelated to indoor environment. The unrelated credits that were considered include transport and pedestrian assess and vehicular assess for servicing and waste disposal. The effects of unrelated credits to the overall rating could then be minimized and the overall rating would be a better reflection of the

indoor environmental conditions of the office buildings. The checklist of the 2/96R version of the HK-BEAM scheme is shown in Appendix Three.

Buildings with different ratings including 'Excellent', 'Very Good', 'Good' and 'Fair' were included. Buildings without a certificate were not included for comparison as participation in the HK-BEAM certification scheme was voluntary. Therefore buildings without such certificate may not imply that their performance was not up to the standards specified under the HK-BEAM scheme. The differences in the ratings of the buildings acted as proxies to reflect the differences in the indoor environment.

5.7 Data Collection for Part Two

Face to face questionnaire survey was employed to collect the necessary data. The interviews were targeted specifically on those office workers passing the entrance of the target buildings. The interviews were conducted during lunch time periods. Evening hours were avoided to eliminate over report of complaints about fatigue due to their tiredness at the end of the working day. Lunch time period was selected as the pedestrian flow was higher. Moreover, those office workers still have fresh memories about the health problems they perceived in the morning.

5.8 Data Analysis

In this study, the methods for data analysis followed those used in UK where more studies about building related health complaints were conducted. The guideline—Questionnaire for Studies of Sick Building Syndrome which was published by the Building Research Establishment in 1995 was consulted.

In order to validate whether there were differences in the indoor environmental conditions as perceived by occupants in buildings with different ratings under the HK-BEAM scheme, an index for the perceptions on the indoor environment was constructed for each of the four buildings. It was the Environmental Comfort Index (ECI). The ECI was based on the evaluations of the indoor environment by the occupants. The following responses—clean for air quality, comfortable or suitable for other criteria got a score of 0. All other evaluations about the indoor environment got a score of 1. The index represented the mean of the scores from the occupants of a particular building. It represented the indoor environment of that particular building. The indexes for the four target buildings were compared to see if they were consistent with the ratings of the buildings certificated under the HK-BEAM scheme. Buildings with higher ratings should have lower indexes for the perceptions of the indoor environment. It is because occupants should be more satisfied with the indoor environment in buildings with higher ratings.

Indexes were also used for analyzing the data collected from part two of the questionnaire. The building related symptoms reported by an individual were added to give a Person Symptom Index (PSI). The mean PSI for each building was used to represent the Building Sickness Index (BSI) of that particular building. The BSI revealed the situation of each building. It was used for comparisons between buildings to verify the hypothesis for this study. The BSI was calculated in this way, for each and every symptom perceived by the respondents, if the respondents reported that the symptom was better when they are away from the office, a score of 1 was assigned to that response. A score of 0 was assigned to all other responses. The sum of the scores

from each individual was added to give the PSI. The mean of the PSI of the respondents from a particular building was the BSI of that building.

Equal weighting was applied to every symptom. It was because there is no conclusive evidence about which symptom is more important to the perceptions of building related health complaints. Corrections were applied to reflect the effects of gender and job category. This was necessary as previous studies showed that female and clerical workers are more susceptible to complaining building related health problems. The corrections were carried out simply by applying weightings to the PSI. The weightings were based on those suggested in the guideline from the Building Research Establishment. The corrections in this guideline were based on the situations in the United Kingdom. This might not be representative enough to reflect the situations in Hong Kong. The perceptions on building related health symptoms by Hong Kong people and the work practices in Hong Kong might be different from those in UK. However, as there are no studies about these correction factors in Hong Kong, the UK ones were used in this study. The adjusted Building Sickness Indexes for the four buildings were then compared.

The frequency and intensity of occurrence of each of the perceived symptom were recorded in the questionnaire by the Likert scale ranging from 1 (little/seldom) to 5 (a lot/always). A Frequency and Intensity Index (FII) reflecting the frequencies and intensities of occurrence of symptoms was constructed in the same way as the Building Sickness Index. Correction to the FII was carried out in the same way as that to the BSI by applying the same correction factors. Although those correction factors are intended for the calculation of BSI only, they were still applicable in this case. As

there are no previous studies or guidelines about the corrections factors for the frequency and intensity of symptoms reported, the same correction factors used for BSI was used. The adjusted Frequency and Intensity Indexes for the four buildings were compared.

The above two analysis were to verify if there was a trend for BSI and FII consistent with the differences in the HK-BEAM ratings of the buildings. They were used to validate that a well designed, maintained and managed indoor environment in open-plan offices can reduce health complaints from occupants.

As revealed from previous studies, people are more likely to report building related health symptoms if they perceive less personal control on the indoor environment where they are occupying. One objective of this study is to test if this applies to open-plan offices in Hong Kong. Questions in part two of the questionnaire were used to check if perceptions of lack of personal control on the environmental conditions would result in building related health complaints. The sum of scores on the perceptions of personal control on every aspect of the indoor environment identified was calculated. The scores were used to represent the degree of personal control. The BSI and the degree of personal control were compared and analyzed. This was to test if relationships exist between the BSI and the degree of personal control on the indoor environment.

CHAPTER SIX

FINDINGS AND ANALYSIS

In this chapter, results of the questionnaires used in both Part One and Part Two are presented and analyzed in detail with reference to the objectives of this study. Recommendations are suggested to alleviate the problem of building related health complaints thus to create a better working environment for office workers.

6.1 Results of Part One

Results in Part One list out the building related health symptoms perceived by office workers in Hong Kong. The symptoms are related to respiratory system, eyes, nervous system as well as skin. A total of fourteen symptoms are identified as being common building related symptoms to office workers. They are dry eyes, itching eyes, watering eyes, blocked nose, stuffy nose, runny nose, dry throat, irritating throat, tiredness, lethargy, headache, dry skin, itching skin and irritating skin. These symptoms are incorporated into the questionnaire used in Part Two of the research.

6.2 Results of Part Two

6.2.1 Information about the Buildings

Thirty valid questionnaires were collected from each of the four buildings being studied and this made up the total number of 120 respondents. Table 1 shows the basic information of the four buildings.

	Building A	Building B	Building C	Building D[1]
Location	Wan Chai	Ho Man Tin	Wan Chai	Ap Lei Chau
HK-BEAM Rating	Excellent	Very Good	Good	Fair
HK-BEAM Version	2/96R	2/96R	2/96R	2/96R[2]
Date of Certification	Aug-99	Sep-99	Nov-99	Nov-99

Table 1: Basic Information of the Four Studied Buildings

The results of the study are shown in detail on the tables and graphs in Appendix Four.

6.2.2 Environmental Comfort Index (ECI)

The Environmental Comfort Index (ECI) about the working environment perceived by the respondents was constructed by the method discussed in the Methodology chapter. The results are shown in Table 2.

	Building A	Building B	Building C	Building D
HK-BEAM Rating	Excellent	Very Good	Good	Fair
Environmental Comfort Index	1.27	1.73	1.80	2.37

Table 2: Environmental Comfort Index

The Environmental Comfort Index (ECI) represents the perceptions of the environmental comfort by the respondents. The results show a general increase in ECI

[1] As requested by the HK-BEAM certificating company, the name and other sensitive information about the buildings could not be disclosed. It is because disclosure may affect the reputation of the buildings, especially those buildings with low ratings.

[2] 2/96R is the version for assessing existing air-conditioned buildings.

when the rating of the building decreases in grade. The higher the ECI, the more uncomfortable the environment is as perceived by the respondents. Therefore, the results show that the higher the rating of the building under the HK-BEAM scheme, the better the indoor environment is as perceived by the occupants.

Among the indoor environmental factors identified, people are more satisfied with the lighting and noise levels and are relatively less satisfied with the indoor air quality. The percentages for complaints about the air being polluted or the ventilation rate being not appropriate are relatively higher. The occupants considered the air either being too draughty or too stuffy. They also perceived the relative humidity was too low which made them perceive the air being too dry. Moreover, there are also a relatively higher percentage of respondents dissatisfied with the indoor air temperature. All the above indicate that the air handling and ventilation system is of prominent importance for the indoor environmental conditions in air-conditioned buildings. It is because those air handling and ventilation systems affect the indoor air temperature, the relative humidity as well as the indoor air quality of buildings.

6.2.3 Personal Well-being

6.2.3.1. Building Sickness Index (BSI)

The main objective of this study is to investigate if the indoor environment of open-plan office would affect the health and well-being of workers. The symptoms reported by the respondents were the main source of data. The Building Sickness Index (BSI) for each of the four building was constructed based on the number of symptoms reported. However, corrections were applied to minimize the effects due to the differences in the gender and job nature of the respondents. The ratios between

male to female respondents and that between respondents with different job natures were different in the four buildings. For example, there were relatively more female respondents from building C and there were relatively more clerks or secretaries response to the study in Building B. As revealed by previous studies, female and people with clerical or secretarial work are more sensitive to the indoor environment. They are more likely to complain about the prevalence of symptoms. It is therefore not a fair comparison by just focusing on the number of symptoms reported because there are differences in the respondents from the four buildings. Corrections were applied based on the guideline mentioned in the Methodology chapter which was based on the correction factors shown in Table 3.

Gender	**Job Nature**		
	Managerial	**Professional**	**Secretarial**
Male	1.000	1.193	1.376
Female	1.324	1.500	1.609

Table 3: Correction Factors for Gender and Job Nature
(Source: Raw (1995) (Ed.) A Questionnaire for Studies of Sick Building Syndrome)

	Building A	**Building B**	**Building C**	**Building D**
HK-BEAM Rating	Excellent	Very Good	Good	Fair
Building Sickness Index (BSI)	1.304	1.508	1.887	2.129

Table 4: Building Sickness Index for Different Buildings

The Building Sickness Indexes for the four buildings are shown in Table 4. It could be observed that the Building Sickness Indexes for all the four buildings are non zero though not very high. It means that out of the eight symptoms on the questionnaire, the respondents from the four buildings reported about one to two symptoms on average. This means that building related health problems are present in open-plan offices in Hong Kong. However, the problems are not very serious in those buildings certificated under the HK-BEAM scheme.

The Building Sickness Indexes show a trend according to the differences in the ratings of the buildings certificated under the HK-BEAM scheme. The higher the rating of the building, the smaller is the BSI. This means that there are less building related health complaints reported by the respondents in the building with a higher rating. The differences in the ratings of the buildings under the HK-BEAM scheme were used as proxies for the differences in the ratings of the indoor environment of the buildings. Hence, there is preliminary evidence that the better the indoor environment, the more comfortable it is as perceived by occupants and there are less building related health problems reported.

Among the symptoms identified, there are comparatively more complaints about dry eyes and tiredness or lethargy. Lighting level in offices should be well considered as there are different user requirements for different tasks. Unsuitable lighting level would cause adverse health effects on occupants. The results show that although people complained about the prevalence of eye symptoms, over 90% of the respondents are satisfied with the lighting level inside the buildings. Therefore, it is believed that unsuitable lighting level may not be the reason for the eye problems

perceived. The problems may be due to the intensive use of computers in offices. It is common for office workers to use computers in their works in Hong Kong. The long period of time they spend in front of computers causes eye strains and tiredness more easily. However, further study to collect information to validate this suggestion is need.

6.2.3.2. Frequency and Intensity Index (FII)

In order to have a more in depth comparison about the effects of the indoor environment on the health of occupants, another index, the Frequency and Intensity Index (FII) was constructed. Corrections to minimize the effects due to the differences in the respondents from different buildings were carried out by applying the same correction factors as in the BSI. The FII represents both the frequency and intensity of occurrence of the building related symptoms as perceived by the respondents from the four buildings. The results are shown in Table 5.

	Building A	**Building B**	**Building C**	**Building D**
HK-BEAM Rating	Excellent	Very Good	Good	Fair
Frequency and Intensity Index (FII)	3.241	3.889	5.205	6.519

Table 5: Frequency and Intensity Index for Different Buildings

There is a correlation between the rating of the building and the FII. It is observed that as the rating of the building changes from Excellent to Fair, the FII increases from 3.241 to 6.519. It means that the higher the rating of the building,

which can be interpreted as the better the indoor environment, the frequency and intensity of occurrence of health complaints are less. This relationship provides another concrete evidence that the indoor environment of buildings would affect the health of occupants.

Both the BSI and the FII conclude that the indoor environment of buildings can affect the health and well-being of occupants. The better the indoor environment, the less the adverse health effects on occupants.

6.2.4 Effects of Building Related Health Complaints

From the survey, about 80% of the respondents that have reported building related health problems claim that their productivities were also reduced. However, only about 10% of those respondents have been absent form work due to this reason. Those symptoms are relatively less serious compared with those clinically proven sicknesses such as fever and bronchitis. Therefore, although the employees are not feeling well, they may not take sick leave.

6.2.5 Personal Control on the Indoor Environment

Another objective of this study is to verify if the perception of lack of personal control on the environment can result in building related health complaints. The total scores for personal control on different aspects of the indoor environment are analyzed with the BSI of the four buildings. The results are shown in Table 6.

	Building A	Building B	Building C	Building D
Building Sickness Index (BSI)	1.304	1.508	1.887	2.129
Sum of Scores for Air Temperature	62	56	55	54
Sum of Scores for Ventilation	65	48	47	44
Sum of Scores for Lighting Level	43	41	40	37
Sum of Scores for Noise Level	41	40	37	35

Table 6: Person Control on the Indoor Environment in Different Buildings

Generally, people perceived that they rarely have control on the lighting level and the noise level around them in all the four buildings. Lighting systems installed in buildings are usually based on the expected requirements in the design stage. It is less likely that the lighting level in such open-plan offices can be adjusted to suit individual needs. For the noise level, most noise is created by human activities in the office; people can hardly have any personal control on the noise level around them. This is true as there are only a few partitions in open-plan offices.

Personal controls on air temperature and ventilation are greater in those buildings. These two aspects of the indoor environment are related to the air-

conditioning systems of buildings. The results suggest that the central air-conditioning systems in the four buildings allow a certain degree of control and monitoring. Responses from management companies to discomforts perceived by occupants were also taken into account for assessing the degree of personal control perceived. This may suggest why there is a higher degree of personal control perceived on these two attributes of the indoor environment. There is also a trend for the degree of personal control on these two aspects of the indoor environment with the BSI. The degree of control is highest in the building with the lowest BSI; however, the differences in the BSI between the remaining three buildings are relatively small.

The results suggest that building related health problems can be alleviated to certain extend by allowing more personal control on the indoor environment. This may be achieved by incorporating effective response mechanisms for those complaints in the building management strategies. However, it should be noted that the results obtained are not significant. The differences between the degrees of personal control perceived in different buildings are quite small. Further researches to collect information are required to confirm the results.

6.3 Recommendations

This study was based on the four buildings with different ratings under the HK-BEAM scheme. The recommendations are therefore based on the analysis of the study results and the performance assessment criteria of the HK-BEAM scheme. As the four buildings are certificated under the 2/96R version of the scheme, the performance assessment criteria are especially referred to this version. The 2/96R version of the HK-BEAM scheme provides guidance for good practice on the

operation, maintenance and management aspects of buildings. It is intended for assessing exiting air-conditioned office buildings. The recommendations are therefore based on these aspects.

Results of this study show that the higher the rating of the building under the HK-BEAM scheme, the lower is the BSI. There are less adverse health effects on occupants in buildings with higher rating under the HK-BEAM scheme. Therefore, performance of buildings with 'Excellent' rating is used for benchmarking. Recommendations are intended to provide guidance for buildings to achieve a good indoor environment. A good indoor environment not only complies with the assessment criteria under the HK-BEAM scheme but also safeguard the health of occupants.

An effective management strategy should ensure the proper operations of all building systems and have well-planned schedule for maintenance works. Proper operation of building systems can also reduce maintenance costs. Generally, there should be well laid-down, easily-to-follow and regularly updated manuals detailing the operation methods, instructions and standard control settings for all building services systems and equipment. Planned program for regular maintenance, cleaning and inspection of the building fabric by specialists is important. Regular cleaning and inspection is especially important for HVAC systems in air-conditioned buildings. It is because HVAC systems have prominent influences on the indoor environment.

In managing the building and the building services systems, use of volatile organic compounds, hazardous materials, radon or asbestos-containing materials

should be avoided. It is because all these materials are harmful to our health. Biological contaminates such as Legionella bacteria in watering systems and HVAC systems should be eliminated.

The air circulation system should be well operated that short circuiting of the exhaust back into the air intake should be prevented. Special attentions should be paid to the outdoor air intakes and exhausts to minimize contaminations to the air circulated in buildings. The ventilation rate should be effective and adequate to allow ambient air distributions indoors. The filters in the air handling units should be carefully selected and well maintained to avoid and minimize indoor respirable suspended particulates. If significant air pollution sources are present, like the photocopying rooms, provision of separate ventilation systems can ensure fewer disturbances to other areas.

The Lighting systems in offices should provide adequate illuminance and contrast for the workplace and prevents glare. The lamps should be cleaned and replaced regularly. They should be replaced at the end of the useful life, when the illuminance drops below the designed level. Replacement till failure occurs is not recommended.

A satisfactory background indoor noise level, which depends on the use of the room, should also be maintained. This is to ensure an ambient working environment for the employees which can safeguard their well-being and prevents reduction in productivities.

The results of this study show that a higher degree of personal control on the indoor environment reduces the occurrence of building related health complaints. This is best achieved by incorporating some mechanisms for control and monitoring in building services systems. Special attentions should be paid to the building management practice. Timely responses to complaints about discomforts perceived by occupants are necessary and useful in minimizing the problem.

CHAPTER SEVEN

CONCLUSIONS

In this chapter, results of the study are compared with the literatures and background information discussed and reviewed in previous chapters so that conclusions for this research can be drawn. The conclusions are discussed with the hypothesis and objectives of the research to validate the significance of this study. Limitations that hinder the effectiveness and efficiency of this study are also explained. Suggestions for further studies in this research area are also explored.

7.1 Conclusions for the Research

This study reveals that Hong Kong is lag behind other countries like Canada and Singapore in the area of indoor environmental controls. Regulatory controls are loosely stipulated and fragmented in various ordinances which are in fact not intended for that purpose. Most legislative controls focus on the ventilation systems while other aspects of the indoor environment are controlled by guidelines and standards. The management and maintenance of building services systems are not regulated by government bodies. Moreover, there is no comprehensive study to reflect situations of the indoor environment in buildings in Hong Kong. This may hinder the effective formulations of government policies to tackle indoor environmental problems.

The empirical study conducted in Hong Kong supports that open-plan offices are susceptible to building related health problems. These problems occur in the four studied office buildings with open-plan layouts. The Building Sickness Index and the Frequency and Intensity Index of the four buildings show that the better the indoor

environment, as reflected by the higher the rating of the building under the HK-BEAM scheme, the less serious is the adverse health impacts on occupants. This empirical study explored the effects of the indoor environment on the health of occupants. It also highlights the importance of creating an ambient indoor environment in buildings. It is important to keep the well-being of occupants to avoid unnecessary reduction in productivities in office workers due to poor indoor environmental conditions.

The findings and results confirm the hypothesis that indoor environment can affect the health of the occupants. The better the indoor environment, the more comfortable it is as perceived by occupants and less adverse health effects are resulted. This arouses the importance of creating an ambient indoor environment for occupants which is usually not of top priority for building designers and property managers.

Open-plan offices in Hong Kong do not allow many personal controls on the indoor environment by occupants. This may be due to the use of central control mechanisms in most building services systems. As a result, occupants perceive a low degree of personal control on the environmental conditions in places where they spend a long period of time everyday. It is therefore of prominent importance that the indoor environment should be well designed by the design team. Moreover, effective monitoring and adjustments to suit the changes in occupancy rates and user requirements by the management company are important. This can ensure an ambient indoor environment is created which safeguard the health of occupant.

Supporting the literatures from previous studies, no conclusive and discrete cause for the occurrence of building related health complaints is identified in this study. In fact, all the systems inside a building interact and inter-related with each other to affect the resulting indoor environment. The indoor environment resulted then affects the health comforts perceived by the occupants. It is therefore important to have careful considerations for creating a good indoor environment during the building design stage. Subsequent proper operations, management and maintenance of all the systems inside buildings during the occupational stage are also important. A benchmarking model for developing an ambient indoor environment in open-plan offices that provides a healthy working environment is developed in this study.

7.2 Limitations

The largest limitation for this study is the limited number of buildings available for investigation. This is mainly due to the lack of information about the indoor environmental conditions of buildings in Hong Kong. As pointed out from the comparative analysis between Hong Kong and overseas countries, there is no database of such kind in Hong Kong. This lack of information hinders the number of buildings suitable for the study. Technical assessments to collect empirical data about the indoor environment of buildings are beyond the ability of the author.

Another limitation for this study is about the personal control on the indoor environment by occupants. The effects of perceived personal control on the environment on the health of occupants cannot be explored in detailed from the results of the empirical study. It is because most buildings have central control systems to monitor the indoor environment. It was originally intended that the degree

of personal control can be explored to certain extent by revealing the practices of the property management companies. If prompt responses are given by the management companies to tackle complaints about the indoor environment, it is treated as having personal control on the indoor environment. However, access to this information is unable. The management companies involved refuse to co-operate because the information needed is sensitive and confidential.

Another limitation is the insufficient resources available. Only the author is responsible for conducting the face to face questionnaire surveys to collect data. A relatively small number of responses were collected. This may affect the significance of the results. Different people have different ways in expressing the questions in the questionnaire and different interpretations for the answers from the respondents. It is not desirable to ask other people who are not familiar with the issue and the technical implications of the questions to conduct the questionnaire survey. The limited time also hinders training and detailed briefing to those potential interviewers difficult.

7.3 Areas for Further Studies

This research provides a preliminary qualitative evidence that the indoor environment of open-plan offices can affect the health of occupants. Poor indoor environmental conditions would have adverse health impacts on the occupants although the syndromes are lessen when the occupants are out of the problem buildings. The findings attract further studies using a quantitative approach to identify which elements in office buildings are most influential to the indoor environment. This would provide hints for people involved in the design and management of office

buildings on how to create an ambient indoor environment to safeguard the health of occupant.

This study focuses on office buildings. Other types of premises are also worth investigating. The approach used in this study can be extended to other types of premises and the results can be compared. Apart from different types of buildings, it is suggested that the Mass Transit Railway stations and the train compartments are also worth investigating.

The large number of various types of buildings in Hong Kong allows a comprehensive study about the indoor environment on the health of occupants to be conducted. A database reflecting such important information can be developed. It can help in setting regulations and standards for tackling building related health problems. Such database can provide valuable information to other Asian countries. It could better reflect the situations in Asian countries compared with those databases developed in the western countries.

The study about the effects of personal control on the indoor environment on the health of occupants is limited in this research. It is worth studying the management strategies of property management companies in handling complaints about indoor environmental comforts. Guidelines on how to tackle the issue of indoor environmental complaints by management companies could then be developed.

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Appendix One: Questionnaire for Part One

Office Environment Survey—Part One
辦公室環境問卷調查---第一部份

This questionnaire concerns about the indoor environment of your office on your health.
這問卷是調查您辦公室室內的環境對您健康產生的影響。

I am a Year Three student from the University of Hong Kong, Faculty of Architecture. I am now conducting a research on the effects of indoor environment on the health and comfort of occupants in office buildings in Hong Kong. The success of the study highly depends on your valuable opinions.
本人是香港大學建築學院三年級學生，現正研究辦公室室內環境對用戶健康產生的影響及用戶對香港辦公室樓宇環境舒適度的意見。這項研究成功與否有賴您的寶貴意見。

The questionnaire only takes you several minutes. Any information you provide will be treated in strict confidential and will not be shown or passed to anyone else except with your approval.
填妥此問卷只需數分鐘，您提供的資料將會保密，未得您的同意絕對不會公開。

Question:
問題

Please list out any health problems that you perceived while working in your office but feel better when you are away from it.
請列舉任何您在工作環境中感到，但離開了卻感受不到的健康問題。

_____

_____

_____

_____

Appendix Two: Questionnaire for Part Two

Office Environment Survey—Part Two
辦公室環境問卷調查---第二部份

This questionnaire concerns about the indoor environment of your office on your health.
這問卷是調查您辦公室室內的環境對您健康產生的影響。

I am a Year Three student from the University of Hong Kong, Faculty of Architecture. I am now conducting a research on the effects of indoor environment on the health and comfort of occupants in office buildings in Hong Kong. The success of the study highly depends on your valuable opinions.
本人是香港大學建築學院三年級學生，現正研究辦公室室內環境對用戶健康產生的影響及用戶對香港辦公室樓宇環境舒適度的意見。這項研究成功與否有賴您的寶貴意見。

The questionnaire only takes you several minutes. Any information you provide will be treated in strict confidential and will not be shown or passed to anyone else except with your approval.
填妥此問卷只需數分鐘，您提供的資料將會保密，未得您的同意絕對不會公開。

Part One: Environmental Comfort
第一部份: 環境舒適度

How comfortable do you feel about the working conditions of your office? (*Please circle the option that you think most suitable for your perceptions)*
請圈出您對您工作環境的感覺：

Air Temperature **空氣溫度**	Too hot 太熱	Comfortable 舒適	Too cold 太冷
Air Quality **空氣質素**	Draughty 乾燥	Comfortable 舒適	Stuffy 悶熱
	Clean 清潔		Polluted 受污染
Relative Humidity **相對濕度**	Too dry 太乾	Comfortable 舒適	Too humid 太濕
Lighting Level **光亮度**	Too dim 太暗	Suitable 適中	Too bright 太光
Noise Level **噪音量**	Too quiet 太靜	Suitable 適中	Too noisy 太噪吵

Part Two: Personal Control on the Working Environment

第二部份: 個人對工作環境擁有的控制權

1. How much control do you personally have over the following aspects of your working environment? (including complaints to the management company and prompt and satisfied responses are received afterwards) (*Please circle the option that you think most suitable for your perceptions)*
請圈出最能形容您對以下工作環境範疇控制權的程度: (若管理公司能對你的投訴作出及時而且適當的回應， 可視作擁有控制權)

Air Temperature **空氣溫度**	None at all 完全不能控制	1	2	3	4	5	Full control 完全控制
Ventilation **空氣流通度**	None at all 完全不能控制	1	2	3	4	5	Full control 完全控制
Lighting Level **光亮度**	None at all 完全不能控制	1	2	3	4	5	Full control 完全控制
Noise Level **噪音量**	None at all 完全不能控制	1	2	3	4	5	Full control 完全控制

Part Three: Personal Well-being
第三部份: 個人健康情況

Have you experienced the following symptoms when working in the office? (please √)
當您在辦公室工作時，有否曾經出現以下病徵 ？ (請以√表示)

1. **Dry eyes (眼睛乾澀)** [ ]Yes 有 [ ]No 沒有
If 'Yes', was it better on days away from the office?
如果'有', 那麼離開辦公室後有沒有改善? [ ]Yes 有 [ ]No 沒有

How do you rank the frequency and intensity of occurrence of the symptom?
這病徵的嚴重程度及出現的頻密度可列爲：

Little/Seldom 輕微/偶然	1	2	3	4	5	A lot/Always 嚴重/經常

2. **Itching or watering eyes (眼睛痕癢, 有眼水)** [ ]Yes 有 [ ]No 沒有
If 'Yes', was it better on days away from the office?
如果'有', 那麼離開辦公室後有沒有改善? [ ]Yes 有 [ ]No 沒有

How do you rank the frequency and intensity of occurrence of the symptom?
這病徵的嚴重程度及出現的頻密度可列爲：

Little/Seldom 輕微/偶然	1	2	3	4	5	A lot/Always 嚴重/經常

3. **Blocked or stuffy nose (鼻塞)** [ ]Yes 有 [ ]No 沒有
If 'Yes', was it better on days away from the office?
如果'有', 那麼離開辦公室後有沒有改善? [ ]Yes 有 [ ]No 沒有

How do you rank the frequency and intensity of occurrence of the symptom?

這病徵的嚴重程度及出現的頻密度可列爲：

Little/Seldom 輕微/偶然					A lot/Always 嚴重/經常
1	2	3	4	5	

4. **Runny nose (流鼻水)** [ ]Yes 有 [ ]No 沒有

If 'Yes', was it better on days away from the office?
如果'有', 那麼離開辦公室後有沒有改善? [ ]Yes 有 [ ]No 沒有

How do you rank the frequency and intensity of occurrence of the symptom?
這病徵的嚴重程度及出現的頻密度可列爲：

Little/Seldom 輕微/偶然					A lot/Always 嚴重/經常
1	2	3	4	5	

5. **Dry/ irritating throat (喉嚨乾)?** [ ]Yes 有 [ ]No 沒有

If 'Yes', was it better on days away from the office?
如果'有', 那麼離開辦公室後有沒有改善? [ ]Yes 有 [ ]No 沒有

How do you rank the frequency and intensity of occurrence of the symptom?
這病徵的嚴重程度及出現的頻密度可列爲：

little/Seldom 輕微/偶然					A lot/Always 嚴重/經常
1	2	3	4	5	

6. **Tiredness and/or lethargy (渴睡和/或疲倦)** [ ]Yes 有 [ ]No 沒有

If 'Yes', was it better on days away from the office?
如果'有', 那麼離開辦公室後有沒有改善? [ ]Yes 有 [ ]No 沒有

How do you rank the frequency and intensity of occurrence of the symptom?
這病徵的嚴重程度及出現的頻密度可列爲：

Little/Seldom 輕微/偶然					A lot/Always 嚴重/經常
1	2	3	4	5	

7. **Headache (頭痛)** [ ]Yes 有 [ ]No 沒有

If 'Yes', was it better on days away from the office?
如果'有', 那麼離開辦公室後有沒有改善? [ ]Yes 有 [ ]No 沒有

How do you rank the frequency and intensity of occurrence of the symptom?
這病徵的嚴重程度及出現的頻密度可列爲：

Little/Seldom 輕微/偶然					A lot/Always 嚴重/經常
1	2	3	4	5	

8. **Dry, itching or irritated skin (皮膚乾燥, 痕癢, 敏感)** [ ]Yes 有 [ ]No 沒有

If 'Yes', was it better on days away from the office?
如果'有', 那麼離開辦公室後有沒有改善? [ ]Yes 有 [ ]No 沒有

How do you rank the frequency and intensity of occurrence of the symptom?
這病徵的嚴重程度及出現的頻密度可列爲：

Little/Seldom 輕微/偶然					A lot/Always 嚴重/經常
1	2	3	4	5	

Do you think the above symptoms affect your productivity?
您認爲以上病徵您有否影響的工作生產力?
[ ]Yes 有 [ ]No 沒有

Do you think the prevalence of the above symptoms is one of the reasons causing your sick leave?
以上病徵是您告假 的其中一個原因嗎?
[ ] Yes 是 [ ] No 不是

Part Four: General Information
第四部份: 一般資料

1. What is your gender? [ ] Male 男 [ ] Female 女
性別

2. What is the nature of your job?
您的工作性質是：
[ ] Managerial 管理 [ ] Professional 專業 [ ] Clerical/ Secretarial 文員/ 秘書
[ ] Others 其他_____ (please specify 請註明)

3. What is the space layout where you are working in?
您工作環境的空間配置是：
[ ] A room for you only 私人工作間 [ ] Open-plan space shared with other colleagues 開放式寫字樓

-Thank You -
多謝!

Appendix Three: Checklist of HK-BEAM (Version 2/96R)

Table I: Summary of Credits and Checklist

GLOBAL ISSUES AND USE OF RESOURCES

Sect:	Credit requirement:	Obtainable Credit:	Credits Obtained:
2.1	**Overall Environmental Policy:**		
	for having an established overall company policy to minimise the impact of the company's buildings on the environment.	**1**	
2.2	**Environmental Purchasing Policy:**		
a)	for a purchasing policy by those responsible for managing the building and services, which encourages the use of timber only from well-managed and identified sources for use in partitions, doors, floors, skirting and other fittings used in areas of the premises under the direct control of the Owner/Operator	**1**	
b)	for a purchasing policy by those responsible for managing the building and services, which excludes the use of: insulation materials manufactured using or containing CFCs or HCFCs; and aerosol sprays containing CFCs or HCFCs; paint containing volatile organic compounds; lead-based primers; and asbestos of any grade or form.	**1**	
2.3	**Energy Management Programme:**		
a)	for having an energy policy and an action plan, with the responsibility for implementation vested in a senior executive	**1**	
b)	for having carried out an energy audit of the building within the previous three years	**1**	
c)	for an energy monitoring and targeting system which sets targets and quantifies savings, together with an energy efficiency improvement investment budget and suitably trained staff to undertake its implementation	**1**	
2.4	**Electrical Energy Consumption:**		
a)	for having undertaken a retrofit programme in 'spaces for common activities' which are under the control of the Owner/Operator and showing an improvement in efficiency, as demonstrated by calculation of installed power density, of 20%, alternatively	**1**	
	for the installation of energy efficient lighting in 'spaces for common activities' which are under the control of the Owner/Operator, such that the overall installed lighting power density for these spaces is 15 W/m^2 or less	**2**	
b)	for designing to an office lighting power density of less than 20 W/m^2	**1**	
	for designing to an office lighting power density of less than 17.5 W/m^2	**2**	
	for designing to an office lighting power density of less than 15 W/m^2	**3**	
c)	for "Tenant Fitting Out Specifications" which specifies the provision of one or more of the following types of lighting control systems: time switching: for example, in office areas which have clear time-tables of occupation; switches linked to occupancy sensors which switch lights off in the absence of occupants; photo-electric switching or dimming system arranged to maximise the use of daylight.	**1**	

d)	where heat recovery is provided on the general exhaust from the air-conditioned spaces	1	
	for providing heat reclaim on chillers for winter space heating or other hot water requirements, or where there is no provision of winter space heating	1	
e)	for air conditioning equipment electricity load of less than 150 kWh/m^2/year	1	
	for air conditioning equipment electricity load of less than 140 kWh/m^2/year	2	
	for air conditioning equipment electricity load of less than 130 kWh/m^2/year	3	
	for air conditioning equipment electricity load of less than 120 kWh/m^2/year	4	
	for air conditioning equipment electricity load of less than 110 kWh/m^2/year	5	
	for air conditioning equipment electricity load of less than 100 kWh/m^2/year	6	
	for air conditioning equipment electricity load of less than 90 kWh/m^2/year	7	
2.5	**Ozone Depleting Substances:**		
a)	where the refrigerants employed in the air conditioning system have an average ozone depletion potential of less than 0.06	1	
	where the refrigerants employed in the air conditioning system have an average ozone depletion potential of less than 0.03	2	
	where the refrigerants employed in the air conditioning system have an ozone depletion potential of zero	3	
or	for demonstrating a phased programme of refrigerant replacement to an average ozone depletion potential of less than 0.03.	1	
b)	for specifying automatic refrigerant leak detection for indoor chiller plant, or specifying monthly manual checking for leakage for outdoor plant, AND specifying full refrigerant recovery during maintenance using approved refrigerant recovery equipment and containers.	1	
c)	where either: a fixed or portable refrigeration recovery unit is provided permanently on site for systems with a refrigerant charge of greater than 15 kg in weight, or a maintenance agreement exists with a qualified contractor using approved equipment	1	
d)	where: no halon-based fixed or portable fire protection systems are used in the building, or a schedule of maintenance and testing of fixed halon fire protection systems has been drawn up with the specific aim of minimising unnecessary emissions of halon	1	
2.6	**Facility for Recycling Materials:**		
	for buildings that incorporate dedicated space(s) for collection, sorting and separate storage of recyclable materials, collected from office premises	1	
	for a management system that provides for the collection and sorting of waste from office premises	1	
Total Credits Under Global Issues		29	

Table 1 : continued

LOCAL ISSUES

3.1	**Electricity Maximum Demand:**		
	for demonstrating peak electricity demand less than 160 VA/m^2 (in typical office areas)	1	
	for demonstrating peak electricity demand less than 140 VA/m^2	2	
	for demonstrating peak electricity demand less than 120 VA/m^2	3	
3.2	**Water Conservation:**		
a)	for providing an arrangement of water meters which permits the monitoring of fresh water consumption by the Owner/Operator for each of the major engineering services, separate from that of tenants	1	
b)	for specifying and detailing fresh water systems which are fitted with: a flow control and balancing system to control flow characteristics of each faucet, for the purposes of water economy, or devices to automatically control the operation of taps and urinals which use fresh water, for the purposes of water conservation	1	
3.3	**Legionella Bacteria from Wet Cooling Towers:**		
	for a building in which: wet cooling towers are not used, or the wet cooling towers use seawater, or the wet cooling towers use water from an acceptable source and are designed and maintained as specified in the Code of Practice for the Prevention of Legionnaires Disease	1	
3.4	**Noise from the Building:**		
	for complying with the acceptable noise levels for neighbouring sensitive receivers in accordance with the Technical Memorandum for the Assessment of Noise from places Other Than Domestic Premises, Public Places or Construction Sites	1	
3.5	**Transport and Pedestrian Access:**		
a)	for achieving at least one of the following: no car parking provided, or restricted provision of car parking space to the minimum required to comply with lease conditions with access which ensures simultaneous free flow of vehicles in and out of the car park	1	
b)	for providing easy and substantially sheltered pedestrian access to a mainstream mass transport system	1	
3.6	**Vehicular Access for Servicing and for Waste Disposal:**		
a)	for providing access for delivery vehicles to the service areas of the building which lies within the site boundary and which are enclosed and/or segregated from pedestrian access routes	1	
b)	for providing access for waste collection vehicles which lies within the site boundary and which are enclosed and/or segregated from pedestrian access routes	1	
3.7	**Building Maintenance:**		
	where a planned programme of regular maintenance, cleaning and inspection of the building's fabric is in operation supported by a comprehensive and easy-to-follow manual	1	
Total Credits Under Local Issues		12	

Table 1 : continued

INDOOR ISSUES

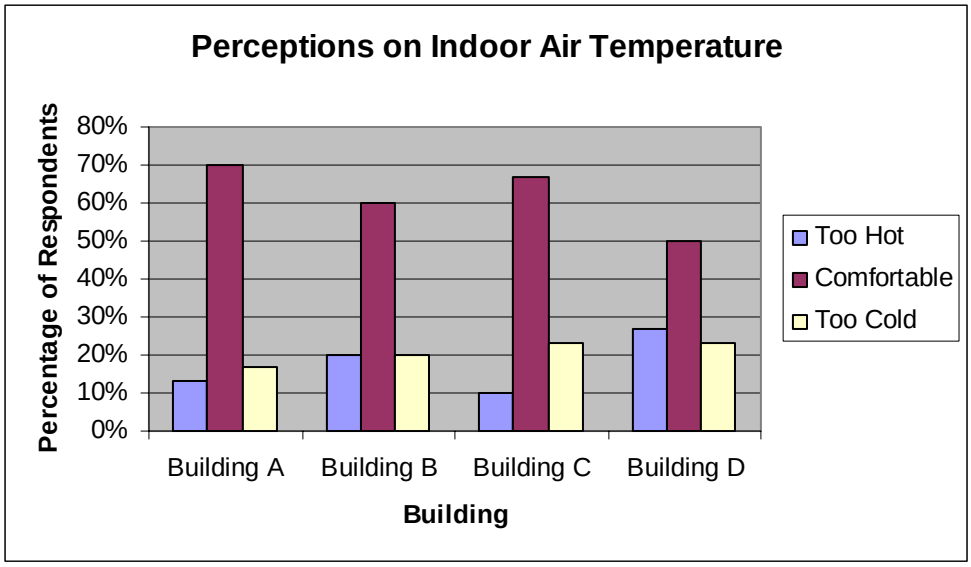
4.1	**Operations and Maintenance of Building Services Systems:**		
a)	for having an easy-to-follow, regularly updated manual detailing the operating methods, instructions and standard control settings for HVAC services equipment	1	
b)	for an established programme of regular inspections, cleaning and maintenance of the building services engineering systems under the authority of a senior executive	1	
4.2	**Metering and Monitoring Equipment:**		
a)	for metering that allows measurement of electricity use and energy consumed by Owner/Operator's major building services systems	1	
b)	for specifying metering which allows separate monitoring of electricity use by the main chiller plant and auxiliaries, and for specifying metering which allows separate monitoring of cooling energy output from the main chiller plant	1	
c)	for metering which allows separate monitoring of electricity use by the air side of the HVAC system	1	
4.3	**Biological Contamination:**		
a)	for complying with the recommendations described in the Code of Practice for the Prevention of Legionnaires Disease that are applicable to indoor HVAC equipment	1	
b)	for complying with the recommendations described in the Code of Practice for the Prevention of Legionnaires Disease that are applicable to domestic water systems	1	
4.4	**Indoor Air Quality:**		
a)	for confirming that the positioning of outdoor air intake(s) and exhaust(s) are such to minimise pre-contamination, prevent short-circuiting of exhaust back into air intakes, and avoid nuisance to neighbours from exhaust discharge(s)	1	
b)	for demonstrating: a ventilation rate of 8 l/s per person or above is achieved in office premises in which smoking is not permitted, or the ventilation rate meets ASHRAE or CIBSE recommended ventilation rate for a smoking environment, or through proper measurement that the carbon dioxide level in offices premises with an occupant density equal or greater than the design density is less than 800 parts per million.	1	
c)	for demonstrating through measurement that the air distribution in the occupied areas of office premises is adequate	1	
d)	for installing filters for intake air and air handling units with dust spot efficiency ≥ 80% tested in accordance with ASHRAE Standard 52.1-92 or European Standard EN-799:1993, or for areas mainly served by fan coil systems installing filters for intake air and air handling units with dust spot efficiency ≥ 80%, and fan coil units with dust spot efficiency ≥ 35%, or demonstrating that the filtration system installed shall be capable of maintaining the indoor respirable suspended particulate level below 180 $\mu g/m^3$ for 24 hour time weighted average	1	
	for specifying filters for intake and recirculating air with dust spot efficiency ≥ 80% or otherwise showing that this higher efficiency is not necessary	1	
e)	for designs which include provision for separate ventilated system for areas where significant indoor pollution sources are present, such as print rooms, etc	1	

4.5	**Mineral Fibres:**		
a)	where the original building specification specifically excluded the use of asbestos in the building, or for having carried out a professional asbestos survey, keeping written record of the location of all asbestos, and taking appropriate action to deal with all asbestos identified	1	
b)	for demonstrating that the following conditions are satisfied: fibrous duct liners are not used inside the ventilation ducts or equipment, excepting coated or uncoated sound attenuation liners up to 4 m in length, or fibrous duct liners inside the ventilation ducts or equipment are covered with durable polymer or foil or similar fibre control, and fibre release is confined to the return air ducts, and uncoated duct liners are not used in supply air ducts.	1	
	where no significant quantities of uncontained man-made mineral fibre materials are located in the air handling plant rooms or air plenums	1	
or	for demonstrating through measurements of unoccupied office areas levels of mineral fibres less than 1000 fibres/m^3	2	
4.6	**Radon:**		
	for having undertaken a radon survey, and for having taken appropriate action where the levels are shown to exceed 200 Bq/m^3	1	
4.7	**Hazardous Materials:**		
a)	for specifying particleboard conforming to British Standard BS 5669 and fibreboard conforming to British Standard BS 1142 excluding use of treated timber where it is not recommended in any relevant codes and standards, and specifying all preserved timber shall be industrially pre-treated ready for finishing on site	1	
b)	for use of paints that contain no lead, and paint containing volatile organic compounds (VOC) conforms to British Standards relating to solvent	1	
4.8	**Interior Lighting:**		
a)	for "Tenant Fitting Out Specifications" which specifies that: fluorescent and other lamps with modulating (fluctuating) output should be fitted with high-frequency ballasts in all the areas used for office work, and lamps shall have a CIE general colour rendering index 80 or above (i.e. colour rendering groups 1A or 1B)	1	
b)	for "Tenant Fitting Out Specifications" which demonstrates by calculations for a typical office floor plan and surface finishes that CIBSE guidelines on the following items of office lighting design are followed: maintained illuminance on the working plane; illuminance variation; and glare	1	
4.9	**Indoor Noise:**		
	for noise levels below the following values: 45 dB $L_{Aeq,T}$ in private offices, small conference rooms. 50 dB $L_{Aeq,T}$ in large offices	1	
Total Credits Under Local Issues		22	
Total Credits Available		63	

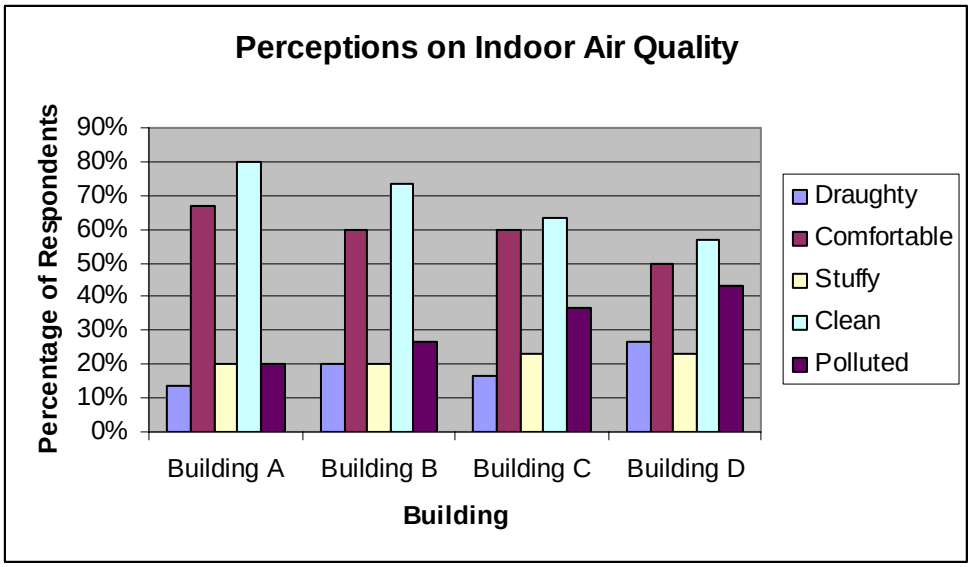
Appendix Four: Results from Part Two

Part One: Environmental Comfort

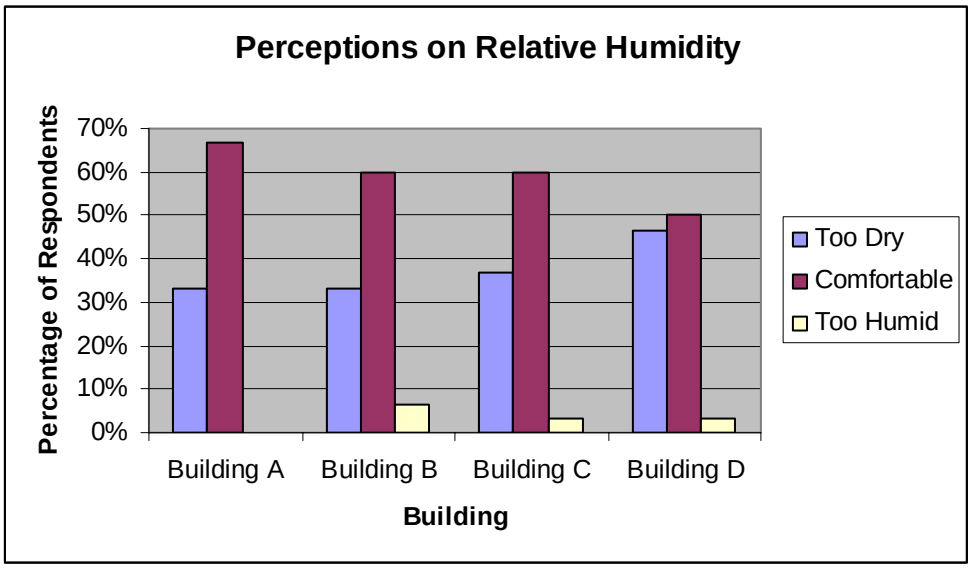
Perceptions on Indoor Air Temperature:



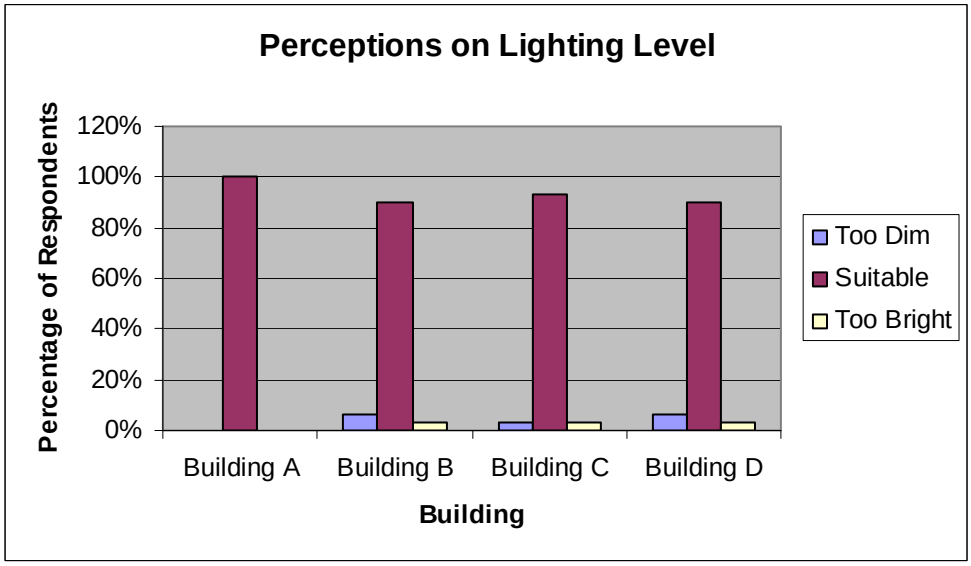
Perceptions on Indoor Air Quality:



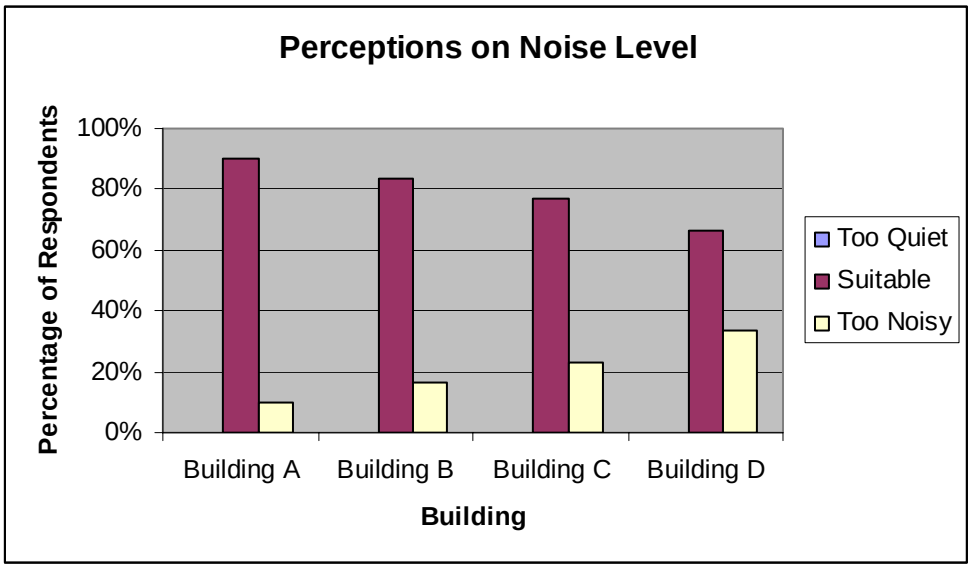
Perceptions on Relative Humidity:



Perceptions on Lighting Level:

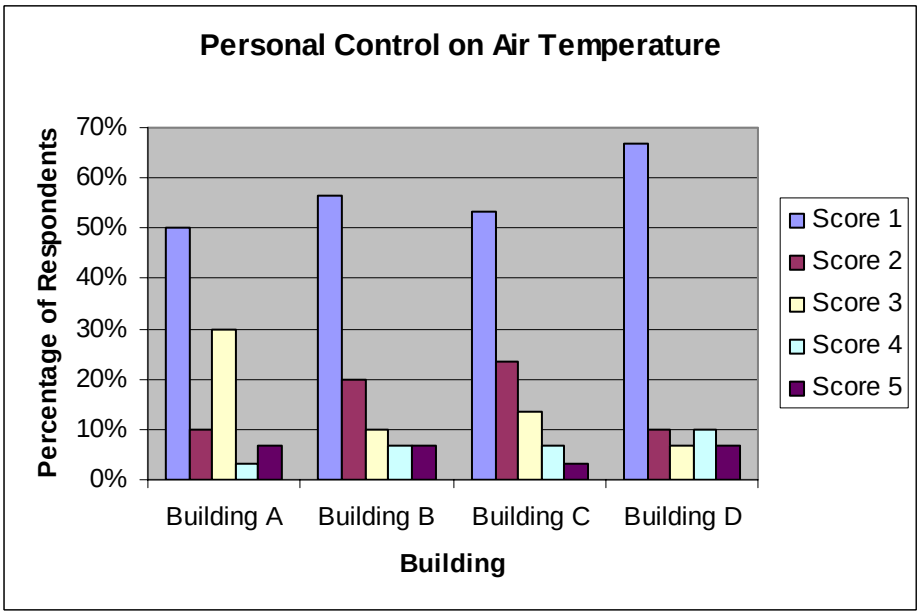


Perceptions on Noise Level:

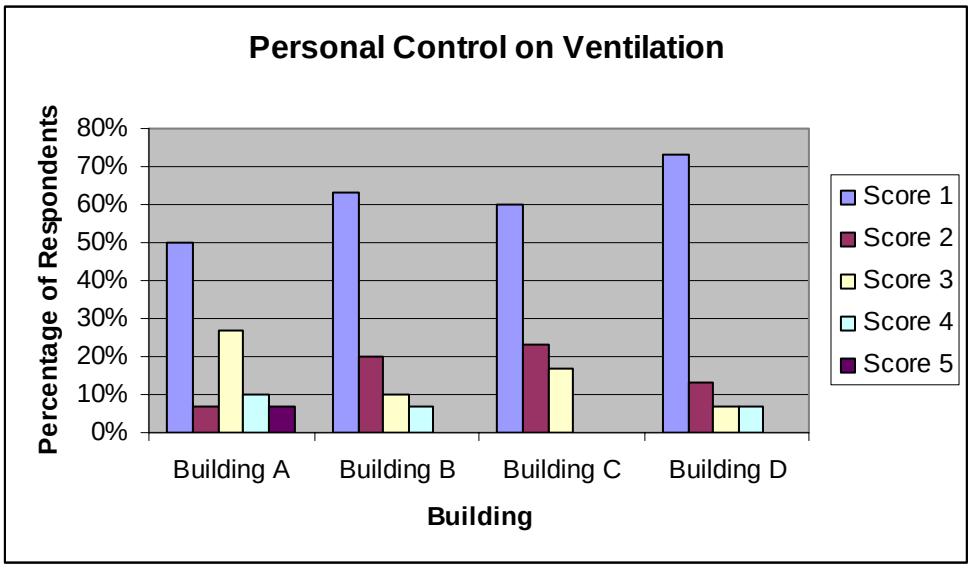


Part Two: Personal Control on the Working Environment

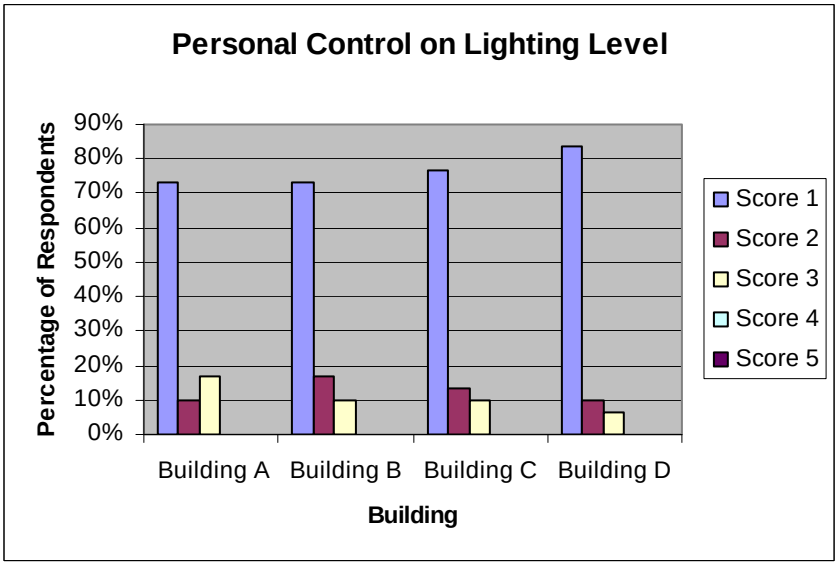
Personal Control on Air Temperature:



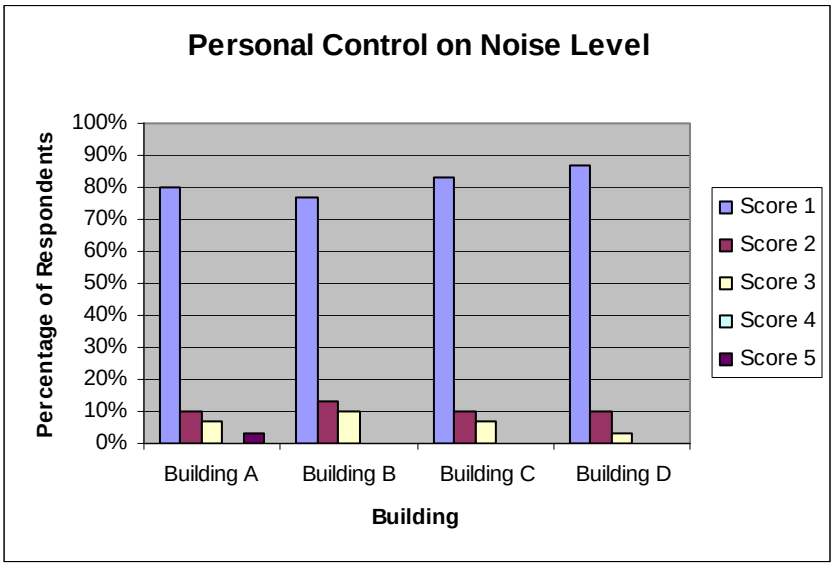
Personal Control on Ventilation:



Personal Control on Lighting Level:



Personal Control on Noise Level:



Part Three: Personal Well-being:

Building A:

Symptom	Yes and Better on Days Away from Office		Rating for Occurrence									
			1		2		3		4		5	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Dry Eyes	13	43.3%	3	23.1%	2	15.4%	6	46.2%	2	15.4%	0	0.0%
Itching/Watering Eyes	8	26.7%	2	25.0%	1	12.5%	4	50.0%	1	12.5%	0	0.0%
Blocked/stuffy nose	2	6.7%	0	0.0%	0	0.0%	1	50.0%	1	50.0%	0	0.0%
Runny Nose	4	13.3%	1	25.0%	1	25.0%	2	50.0%	0	0.0%	0	0.0%
Dry/Irritating Throat	6	20.0%	1	16.7%	2	33.3%	3	50.0%	0	0.0%	0	0.0%
Tiredness and/or Lethargy	15	50.0%	3	20.0%	5	33.3%	4	26.7%	1	6.7%	2	13.3%
Headache	5	16.7%	1	20.0%	1	20.0%	2	40.0%	1	20.0%	0	0.0%
Dry, Itching/Irritated Skin	3	10.0%	1	33.3%	1	33.3%	1	33.3%	0	0.0%	0	0.0%

Building B:

Symptom	Yes and Better on Days Away from Office		Rating for Occurrence									
			1		2		3		4		5	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Dry Eyes	15	50.0%	2	13.3%	3	20.0%	4	26.7%	5	33.3%	1	6.7%
Itching/Watering Eyes	7	23.3%	1	14.3%	2	28.6%	3	42.9%	1	14.3%	0	0.0%
Blocked/stuffy nose	3	10.0%	0	0.0%	1	33.3%	2	66.7%	0	0.0%	0	0.0%
Runny Nose	5	16.7%	2	40.0%	1	20.0%	1	20.0%	1	20.0%	0	0.0%
Dry/Irritating Throat	6	20.0%	1	16.7%	2	33.3%	3	50.0%	0	0.0%	0	0.0%
Tiredness and/or Lethargy	13	43.3%	2	15.4%	4	30.8%	4	30.8%	2	15.4%	1	7.7%
Headache	7	23.3%	1	14.3%	2	28.6%	2	28.6%	2	28.6%	0	0.0%
Dry, Itching/Irritated Skin	7	23.3%	1	14.3%	3	42.9%	2	28.6%	1	14.3%	0	0.0%

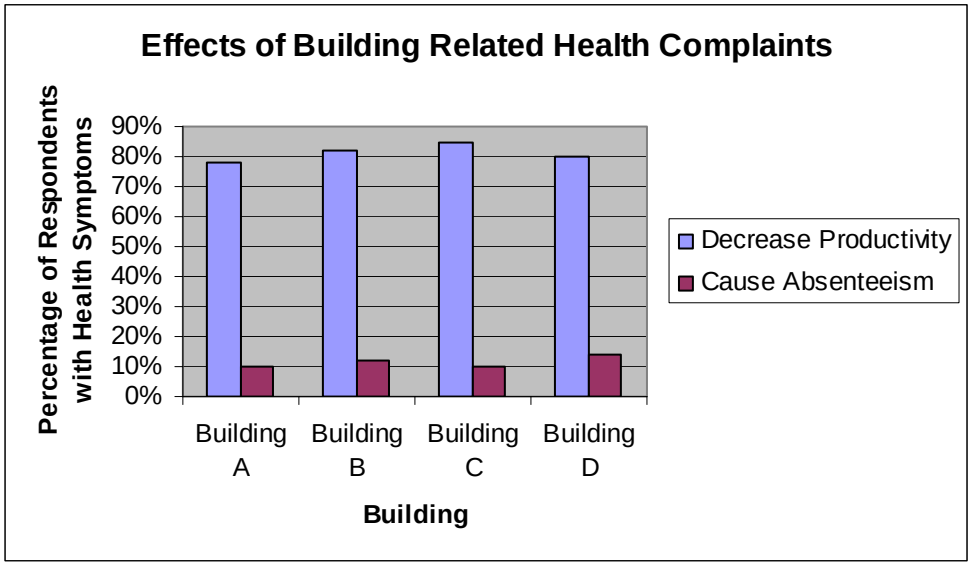
Building C:

Symptom	Yes and Better on Days Away from Office		Rating for Occurrence									
			1		2		3		4		5	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Dry Eyes	16	53.3%	2	12.5%	2	12.5%	6	37.5%	4	25.0%	2	12.5%
Itching/Watering Eyes	9	30.0%	2	22.2%	2	22.2%	3	33.3%	1	11.1%	1	11.1%
Blocked/stuffy nose	4	13.3%	0	0.0%	1	25.0%	1	25.0%	2	50.0%	0	0.0%
Runny Nose	7	23.3%	2	28.6%	1	14.3%	2	28.6%	2	28.6%	0	0.0%
Dry/Irritating Throat	8	26.7%	1	12.5%	2	25.0%	4	50.0%	1	12.5%	0	0.0%
Tiredness and/or Lethargy	15	50.0%	3	20.0%	4	26.7%	4	26.7%	2	13.3%	2	13.3%
Headache	9	30.0%	1	11.1%	3	33.3%	3	33.3%	2	22.2%	0	0.0%
Dry, Itching/Irritated Skin	11	36.7%	2	18.2%	3	27.3%	3	27.3%	2	18.2%	1	9.1%

Building D:

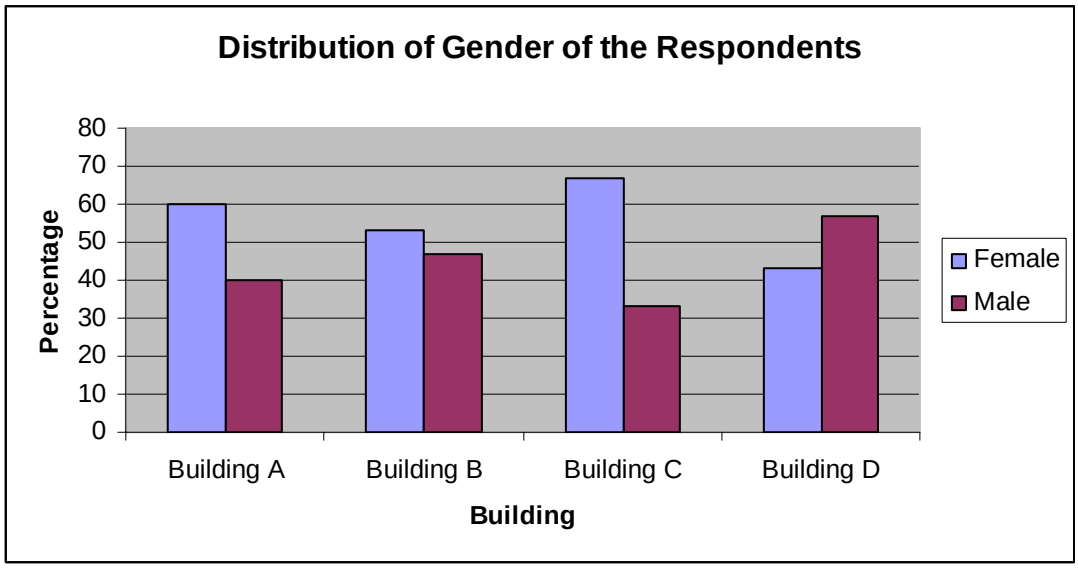
Symptom	Yes and Better on Days Away from Office		Rating for Occurrence									
			1		2		3		4		5	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Dry Eyes	18	60.0%	2	11.1%	2	11.1%	7	38.9%	5	27.8%	2	11.1%
Itching/Watering Eyes	10	33.3%	1	10.0%	2	20.0%	4	40.0%	2	20.0%	1	10.0%
Blocked/stuffy nose	8	26.7%	0	0.0%	2	25.0%	2	25.0%	3	37.5%	1	12.5%
Runny Nose	7	23.3%	1	14.3%	1	14.3%	2	28.6%	3	42.9%	0	0.0%
Dry/Irritating Throat	11	36.7%	1	9.1%	2	18.2%	5	45.5%	1	9.1%	2	18.2%
Tiredness and/or Lethargy	18	60.0%	2	11.1%	3	16.7%	8	44.4%	3	16.7%	2	11.1%
Headache	8	26.7%	1	12.5%	3	37.5%	3	37.5%	1	12.5%	0	0.0%
Dry, Itching/Irritated Skin	12	40.0%	2	16.7%	3	25.0%	4	33.3%	2	16.7%	1	8.3%

Effects of Building Related Health Complaints:



Part Four: General Information:

Gender:



Job Nature: